Carbon Capture, Utilization, and Storage (CCUS) and its Feasibility in Louisiana

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Oil/Gas Industry and Sustainability

- "**Although it was CERAWeek by IHS Markit, it often sounded more like climate week**." *E&E News, March 18, 2019*

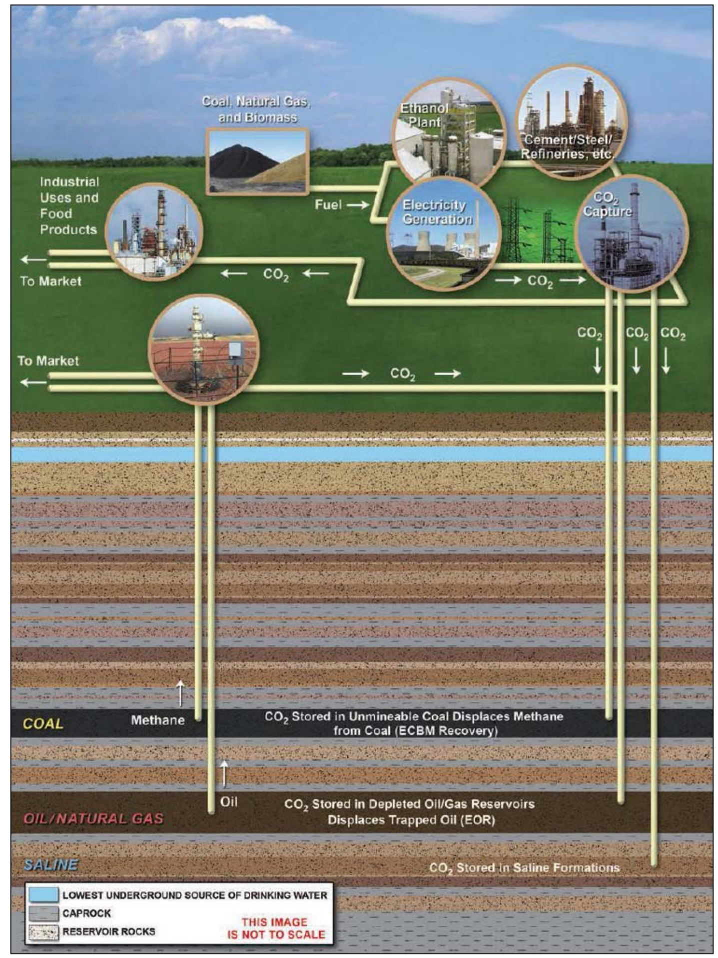
- "**Shell CEO: Climate change is our biggest issue**", *IHS CERAWeek, March 7, 2019*

- "**Oxy CEO: Next gen companies need to be at least carbon neutral**", *Houston Business Journal, March 13, 2019*

- "**Chevron, Oxy invest in CO_2 removal technology**", *REUTERS, Jan 9, 2019*

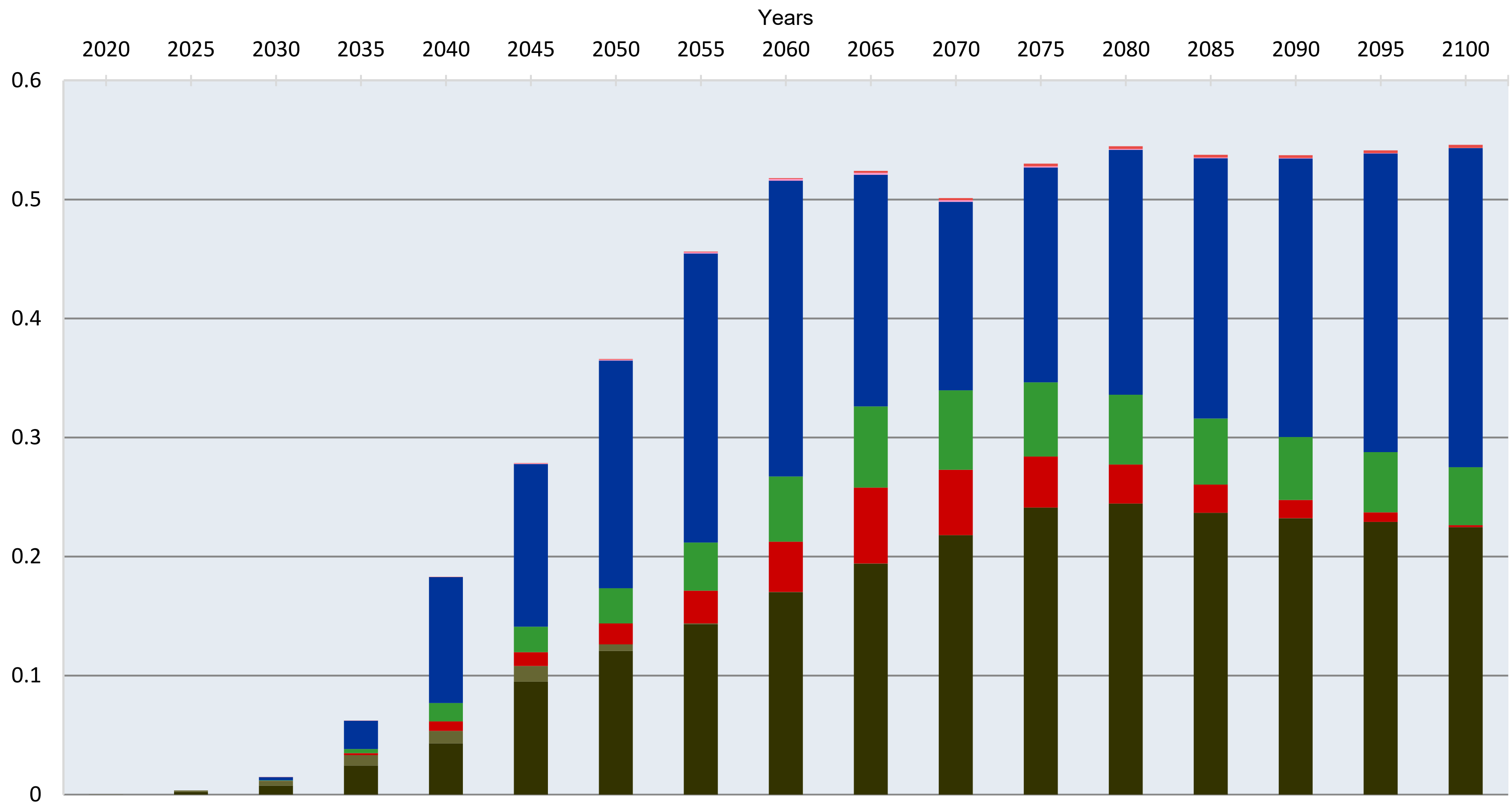
CCUS

- Carbon capture, utilization, and storage (CCUS) involves capturing man-made carbon dioxide (CO_2) at its sources and storing it permanently underground with potential utilization.
- Projections by IEA show that CCUS will need to account for 6 Gton of CO_2 emissions reduction worldwide by 2050.



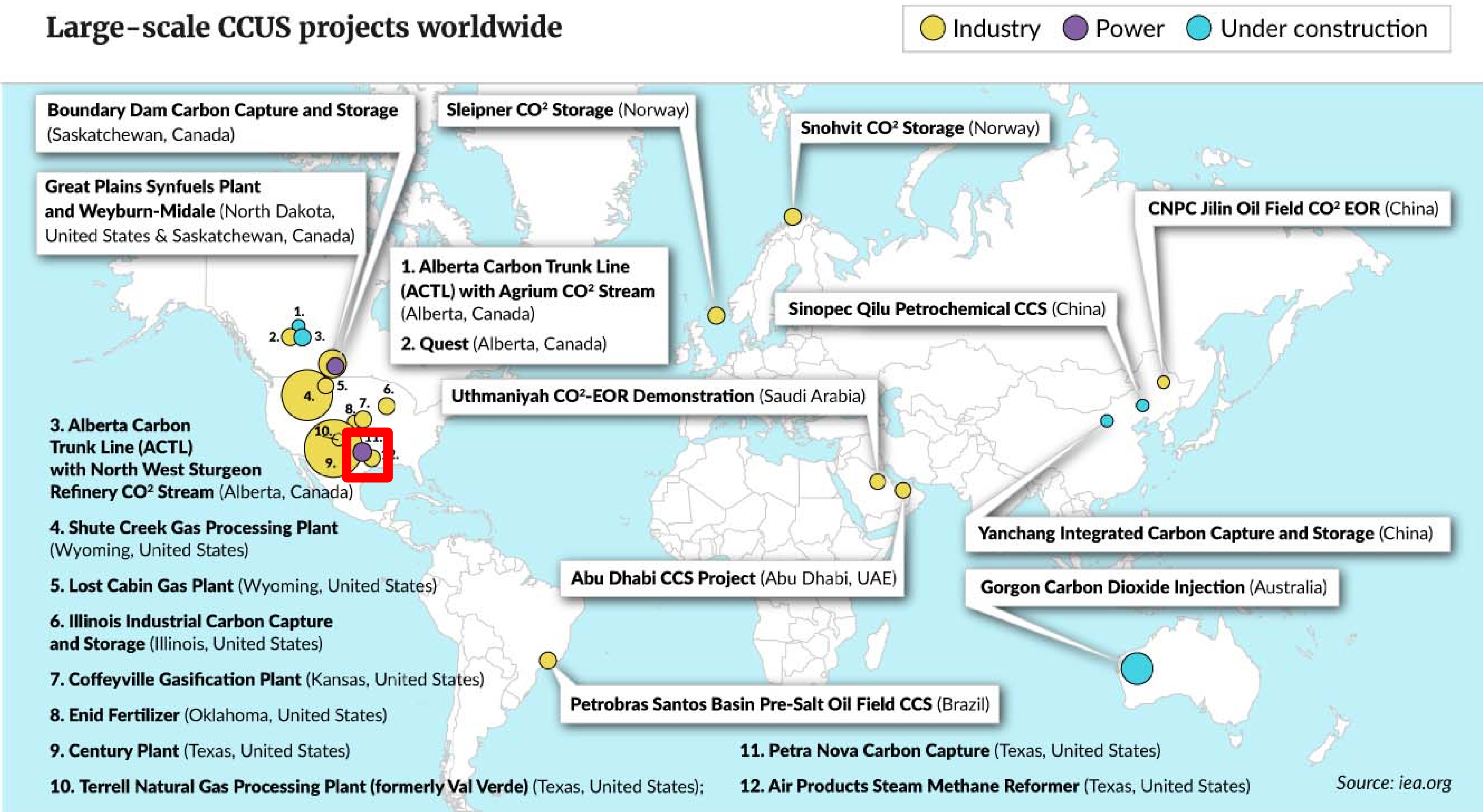
Folger, 2018

CCS Captured CO_2 (Gt/yr) – North America



Shell sky scenario, 2019

Large-scale CCUS projects worldwide

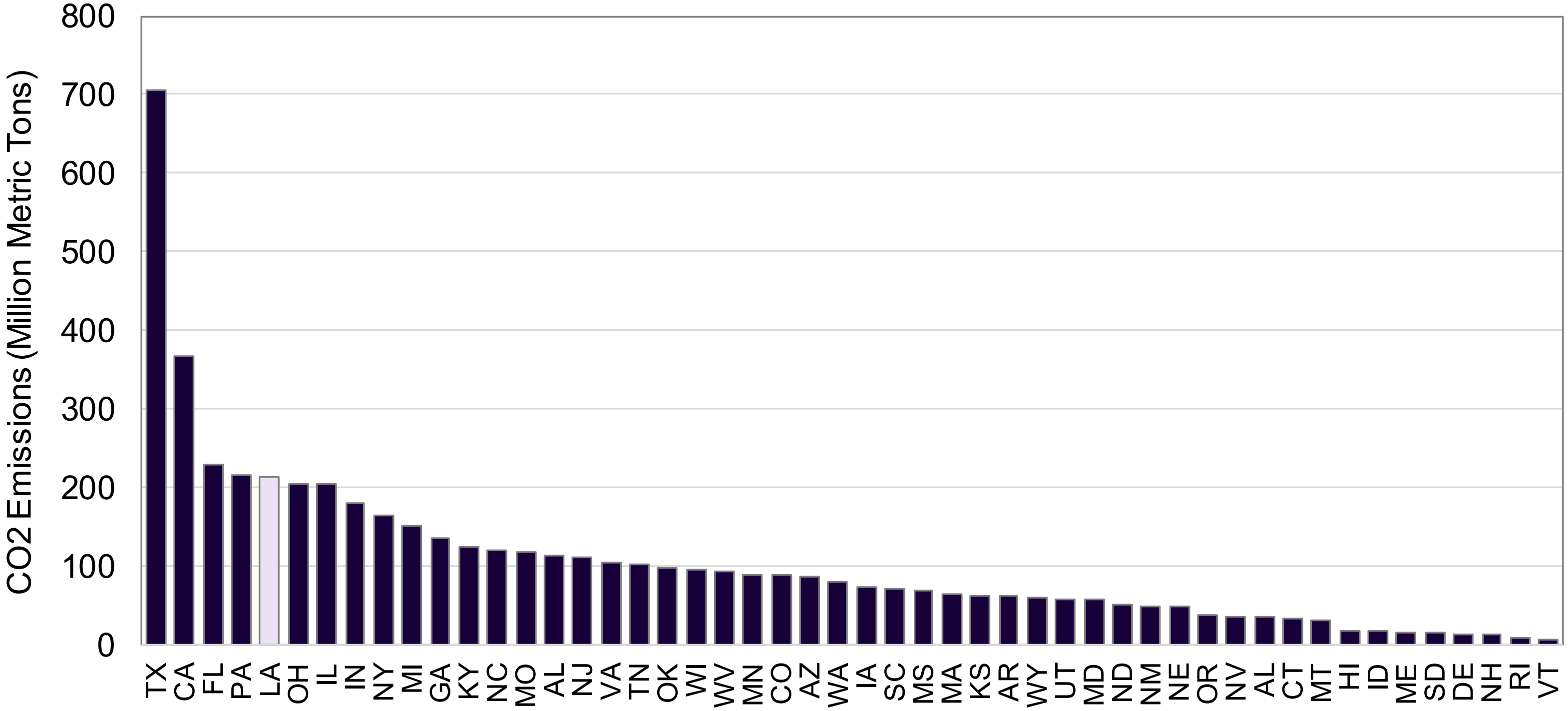


GIS GEOPOLITICAL INTELLIGENCE SERVICES

www.GISreportsonline.com

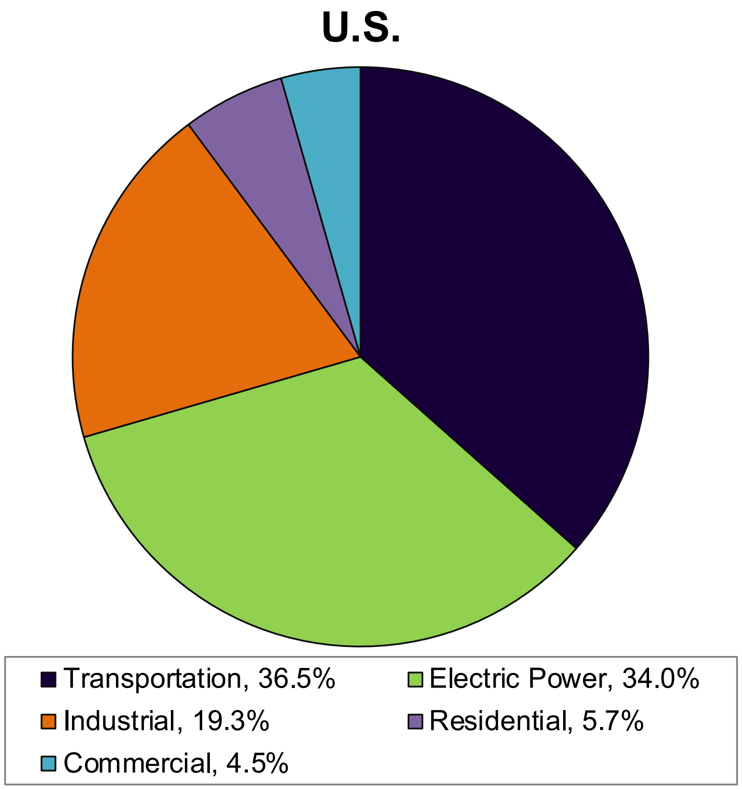
CO_2 Emissions by State, 2016

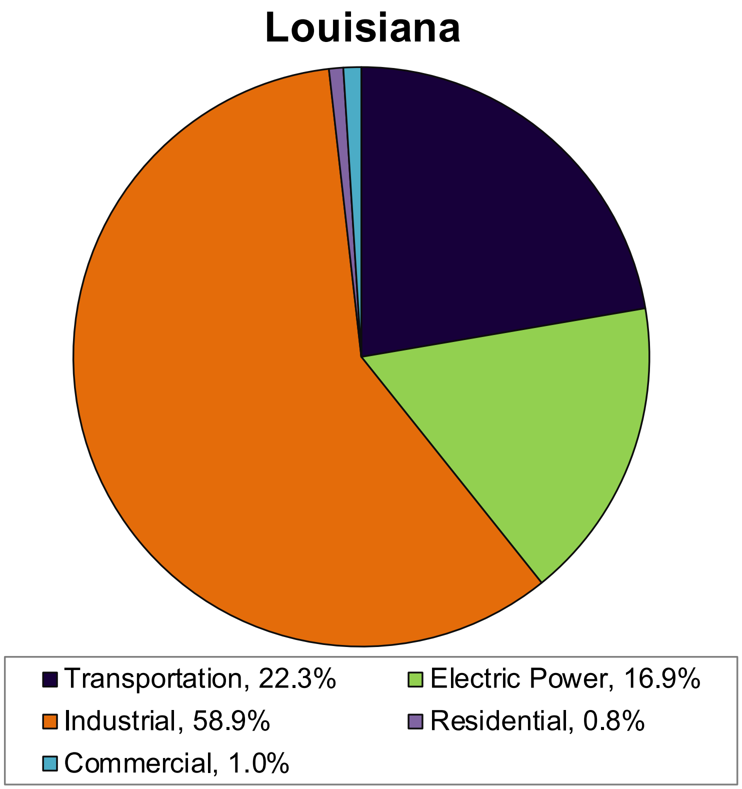
At ~220 million tons of CO_2 emissions, Louisiana ranks fifth in the U.S.



EPA, 2016.

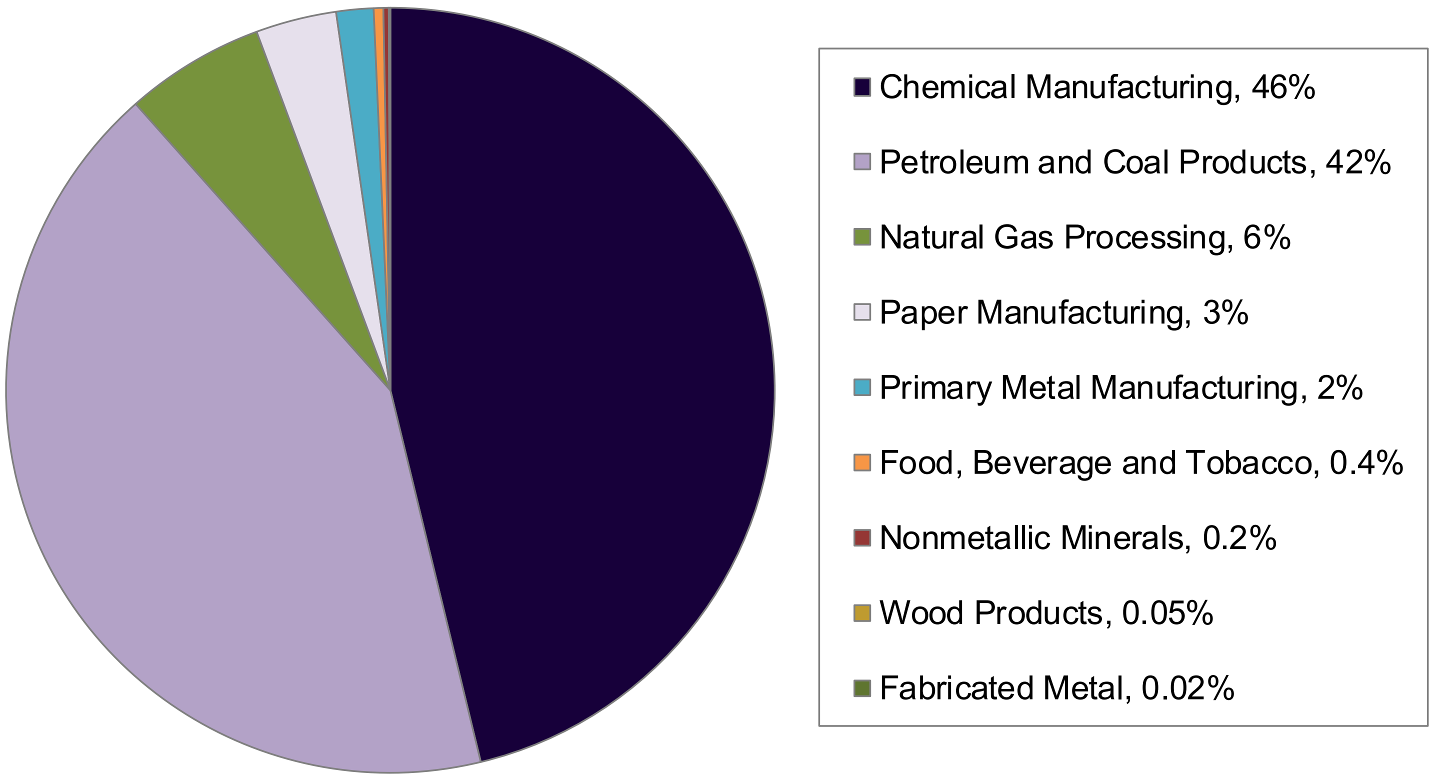
U.S./Louisiana CO_2 Emissions per Sector





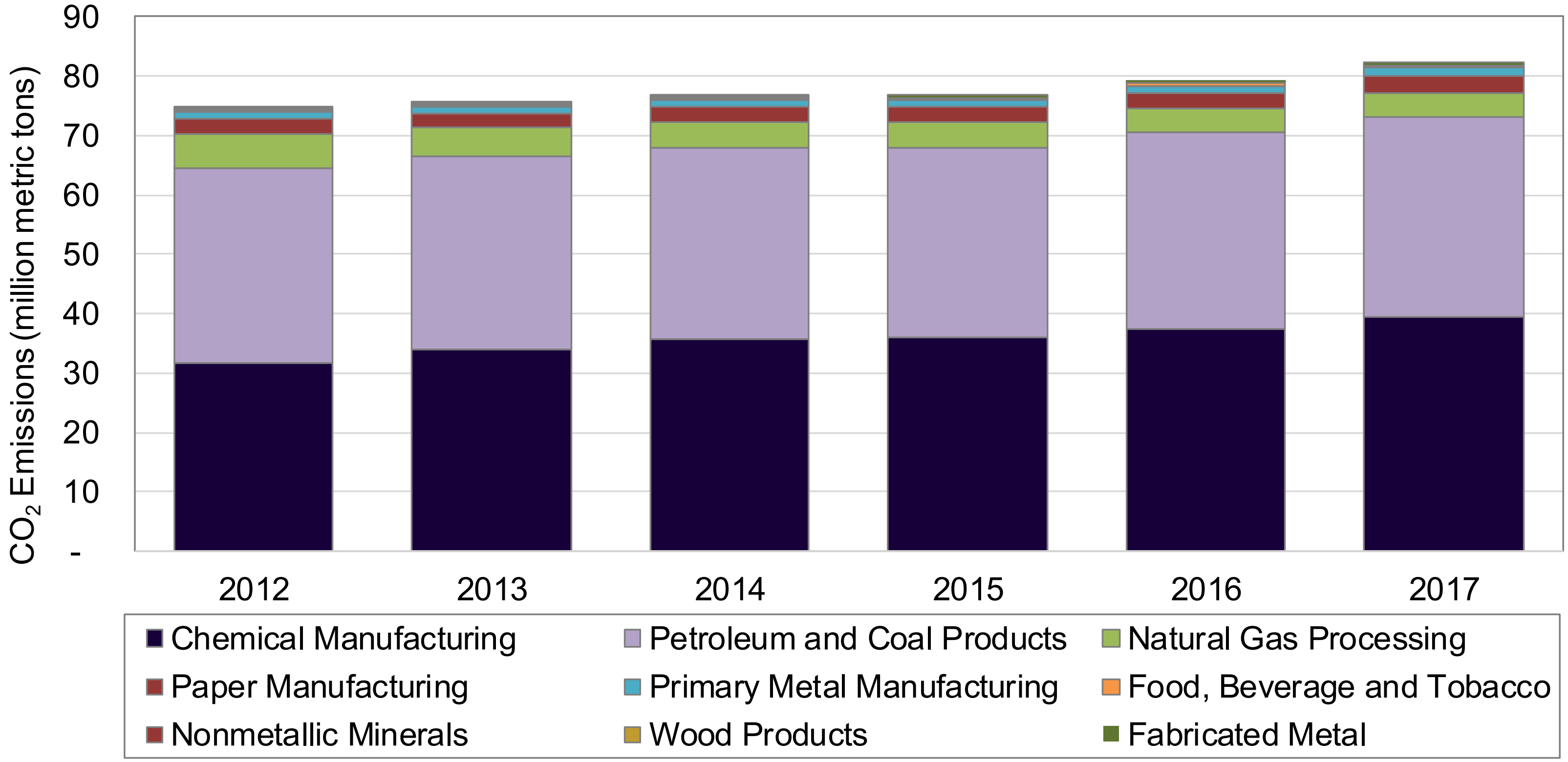
EPA, 2016.

Industrial CO_2 emissions by category



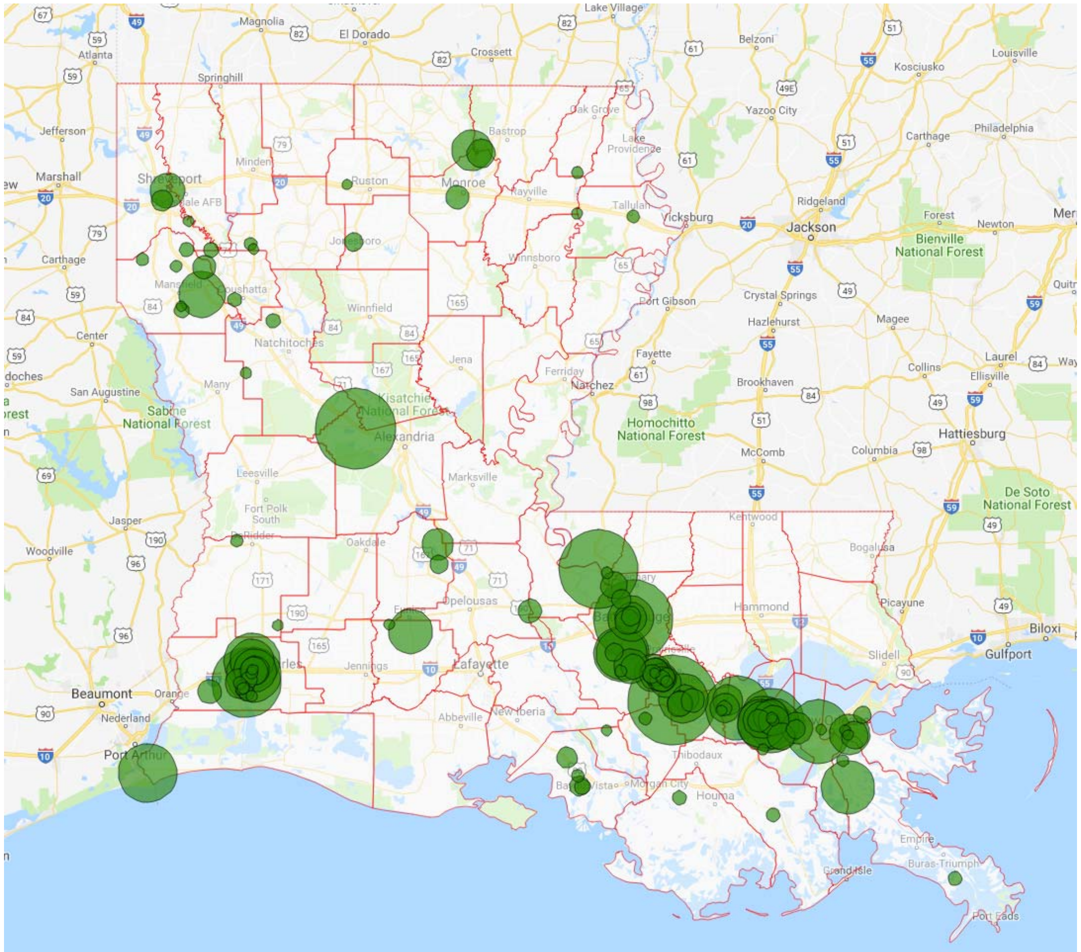
EPA, 2017.

Industrial CO_2 emissions by category



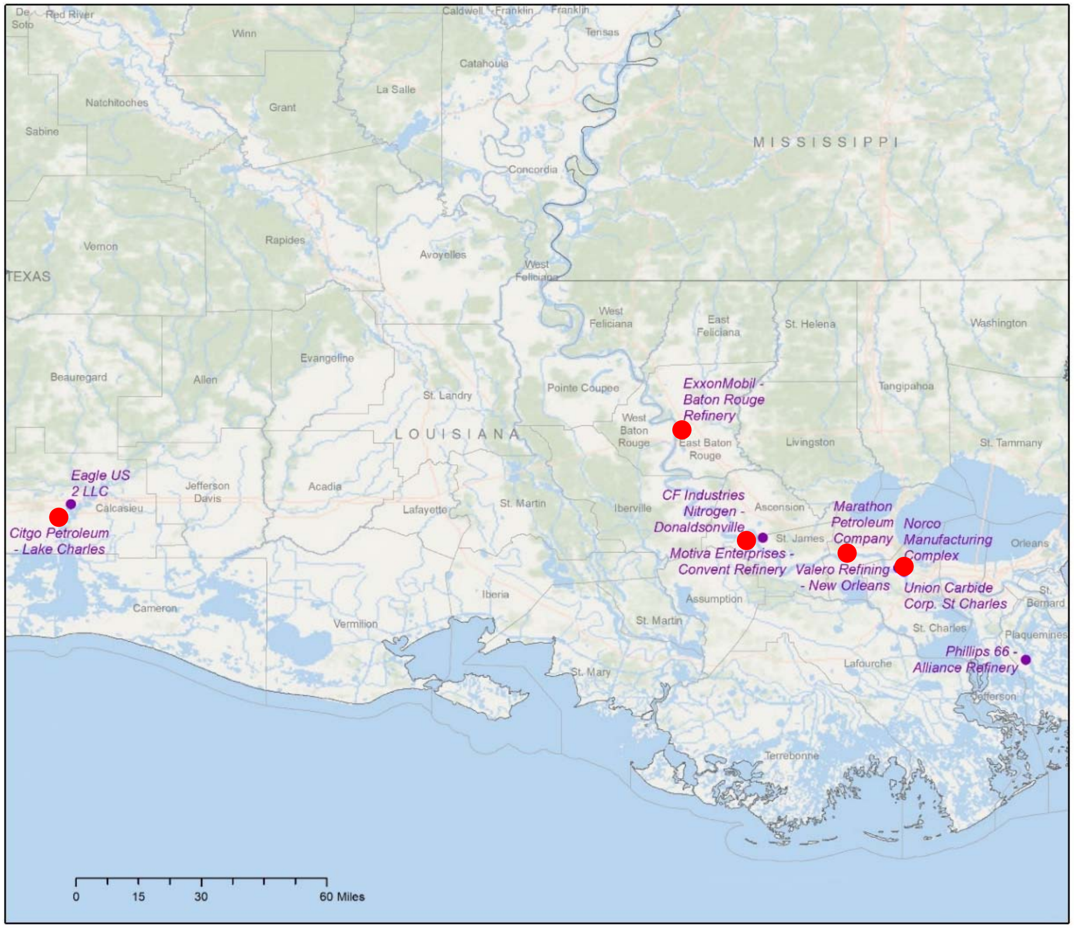
EPA, 2017.

Louisiana CO_2 Sources > 0.1 $MtCO_2$/yr



EPA, 2017

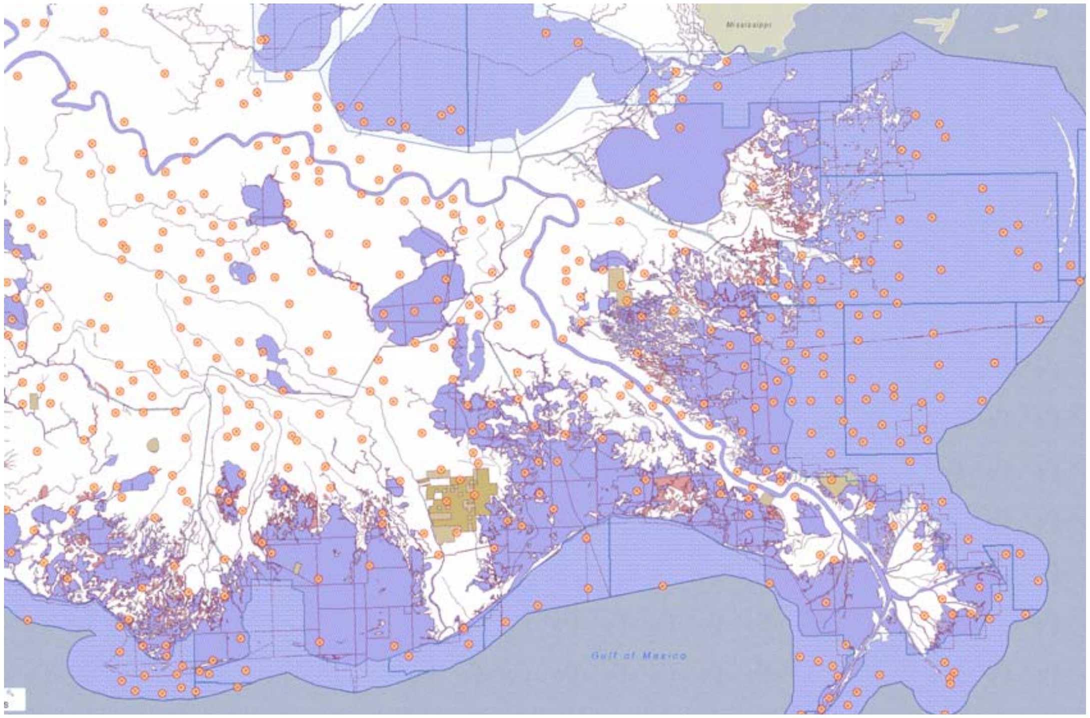
Top Ten South Louisiana Industrial Sources



Dismukes et al., 2019

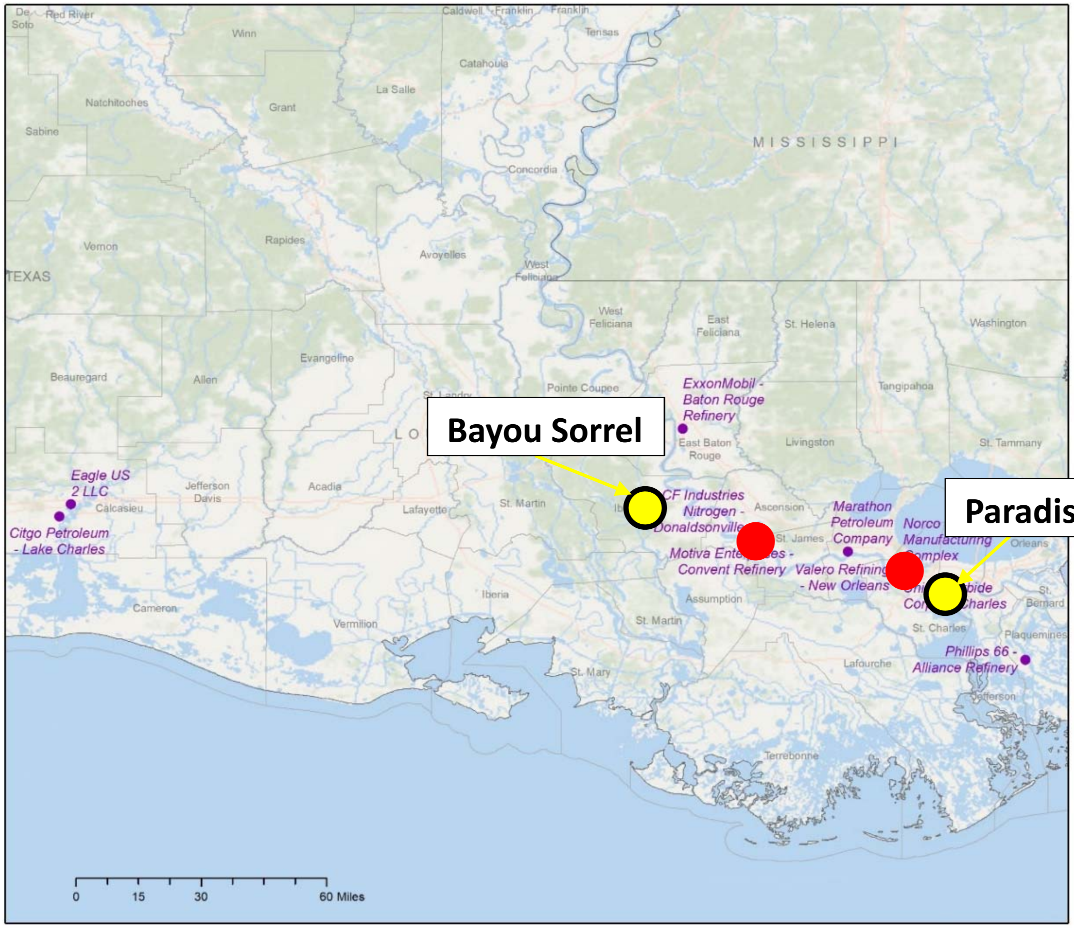
CCUS in Louisiana

- Onshore vs. offshore
- Saline aquifers vs. hydrocarbon-bearing formations



SONRIS, 2019

Identified saline storage sites

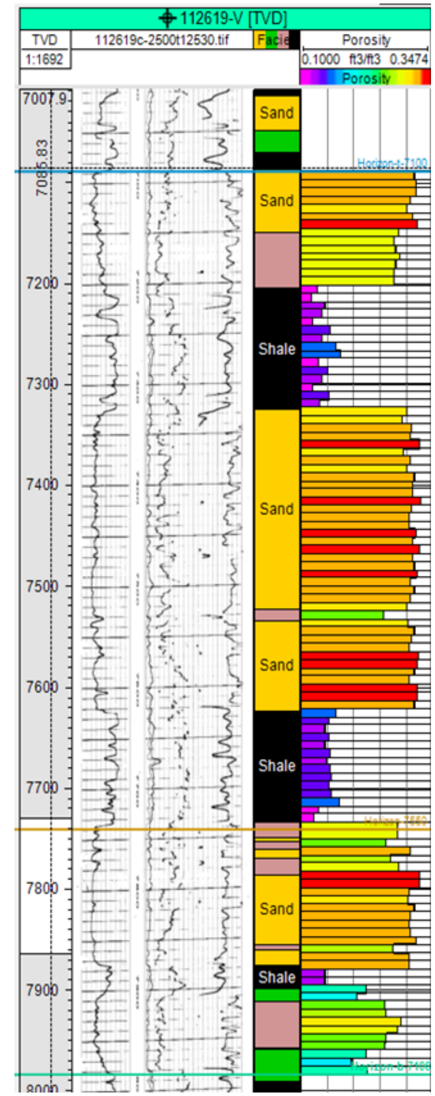


Dismukes et al., 2019

Common features

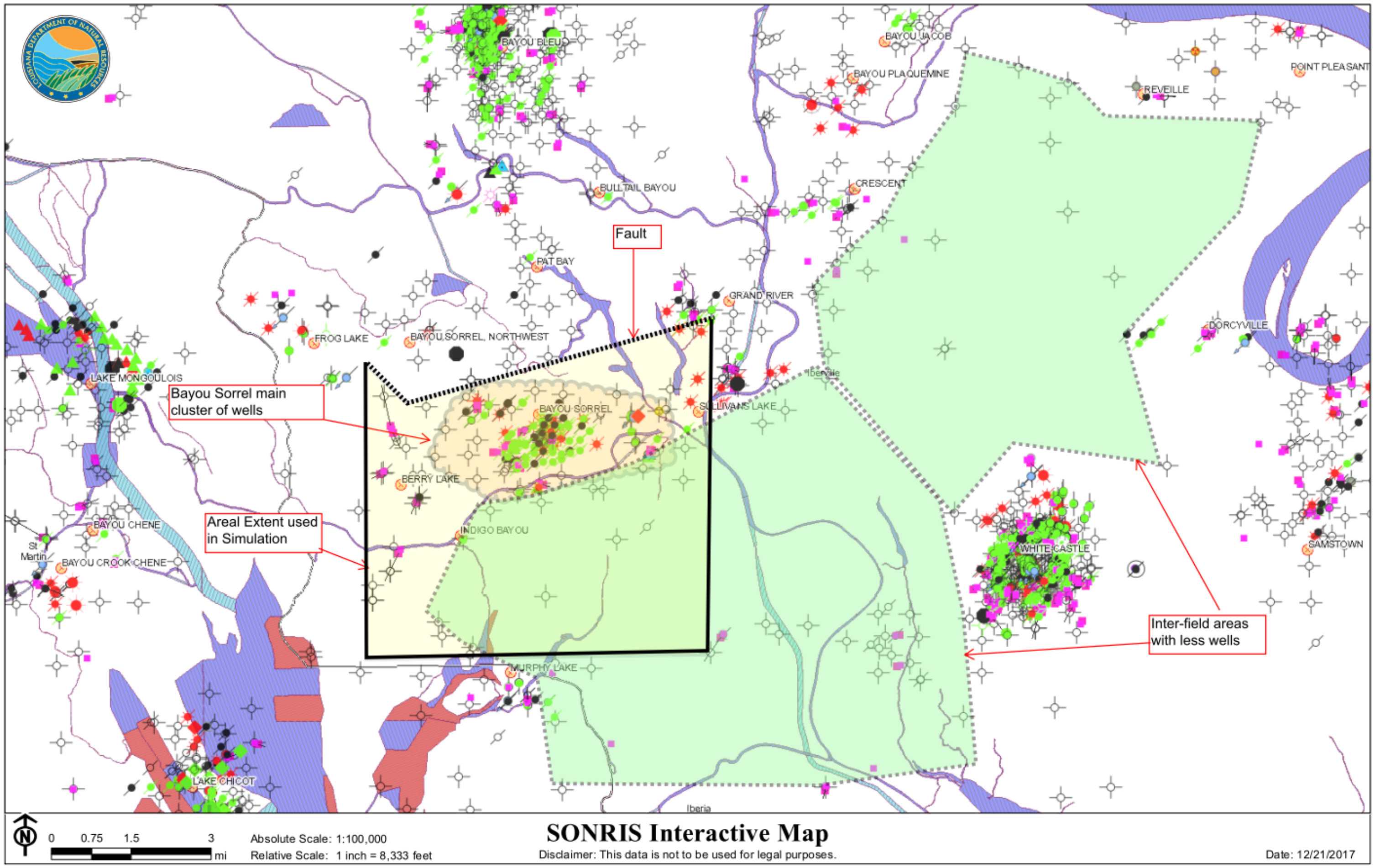
- Multiple storage zones with stacked sand systems
- Thick zones (up to several hundred ft.)
- High porosity and high permeability
- Normal hydrostatic pressure ~0.465 psi/ft

	Cum oil (MMSTB)	Cum gas (BSCF)	Total wells	Currently prod. wells*
Bayou Sorrel	44	190	176	3
Paradis	156	1350	411	16



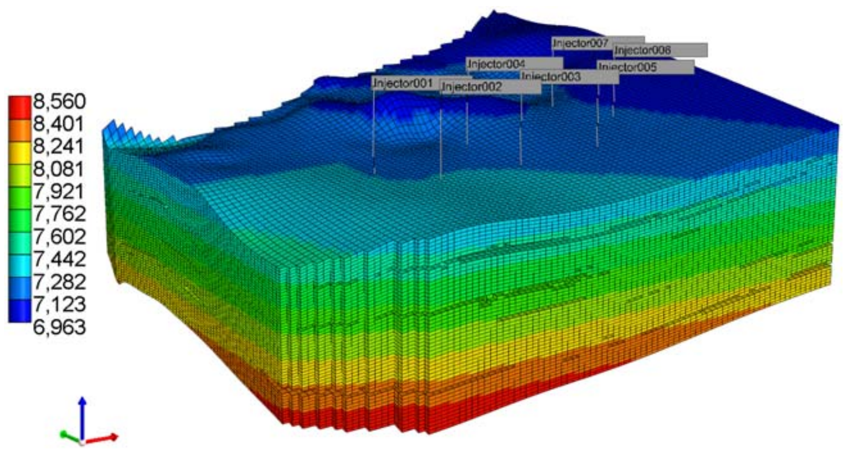
* Current production intervals are deeper than 10,000 ft

Bayou Sorrel



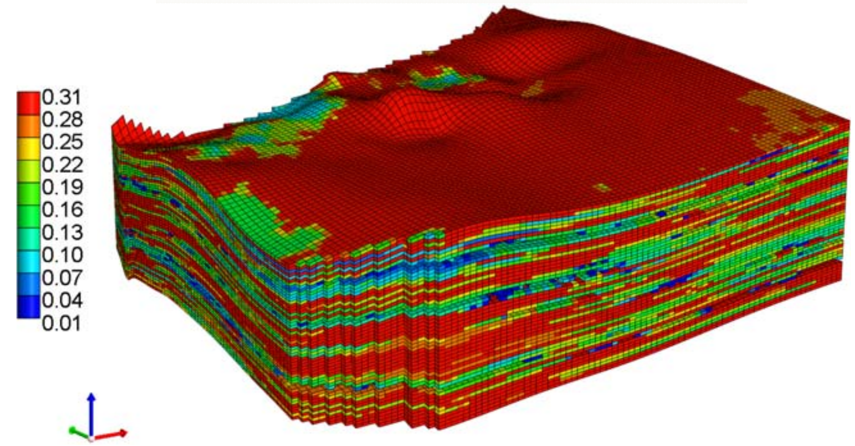
Bayou Sorrel Petrophysical Data

Zone Depth (ft)



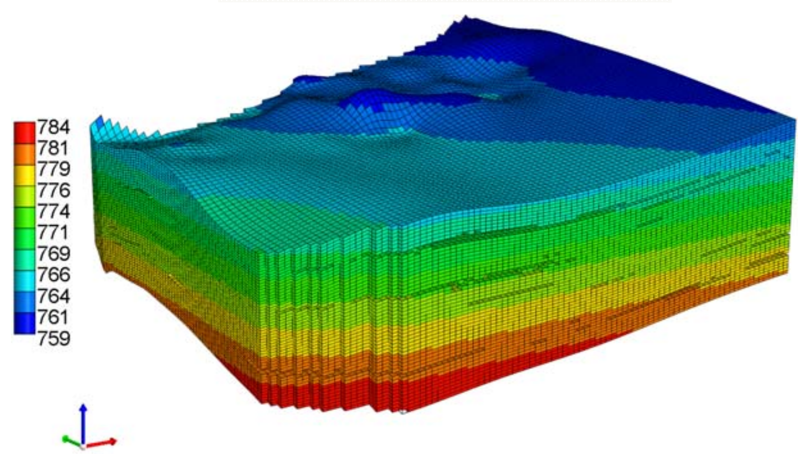
Average thickness = 998 ft

Porosity

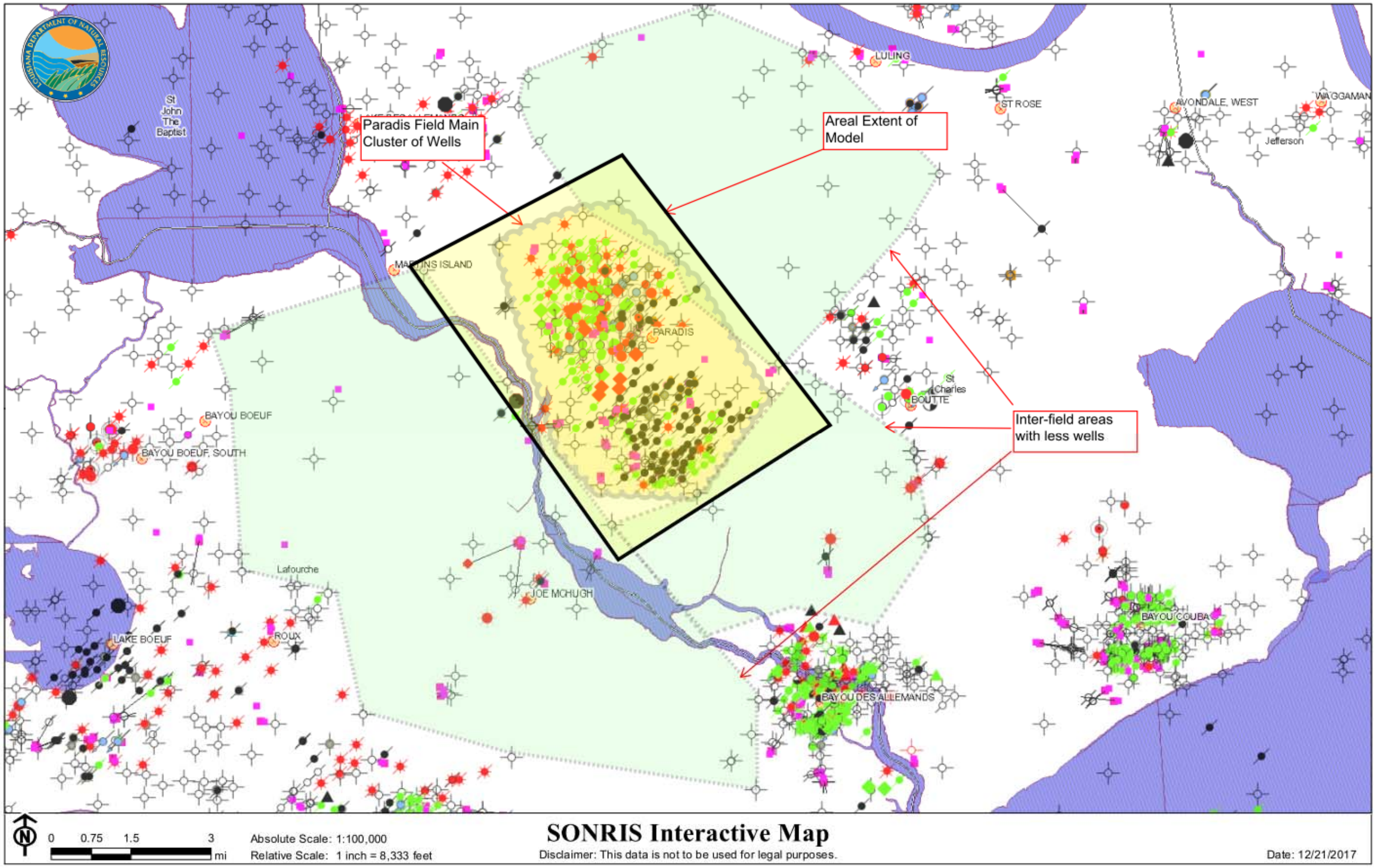


Average Porosity = 0.28

CO_2 Density (kg/m3)



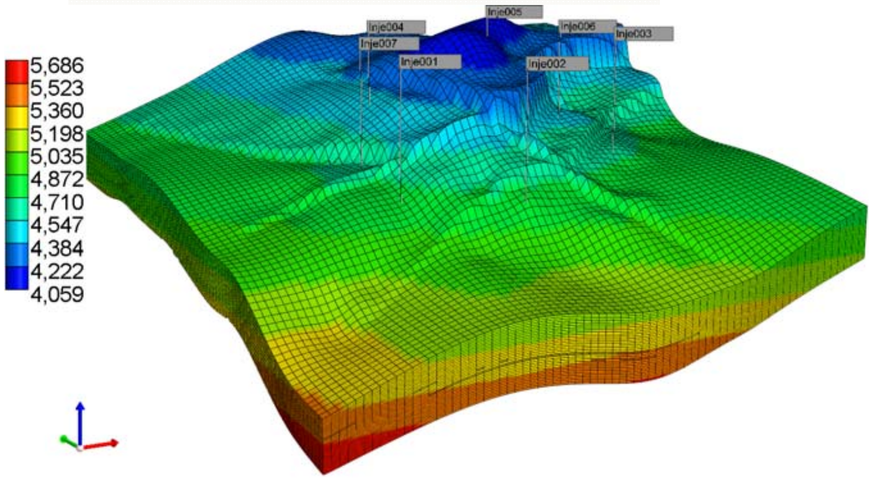
Paradis



Paradis Field Main Cluster of Wells
Areal Extent of Model
Inter-field areas with less wells
St John The Baptist
LULING
ST ROSE
AVONDALE, WEST
WAGGAMAN
Jefferson
MARTINS ISLAND
PARADIS
BAYOU BOEUF
BAYOU BOEUF, SOUTH
St Charles
BOUTTE
Lafourche
JOE MCHUGH
LAKE BOEUF
ROUX
BAYOU COUBA
BAYOU DES ALLEMANDS
0 0.75 1.5 3 mi
Absolute Scale: 1:100,000
Relative Scale: 1 inch = 8,333 feet
SONRIS Interactive Map
Disclaimer: This data is not to be used for legal purposes.
Date: 12/21/2017

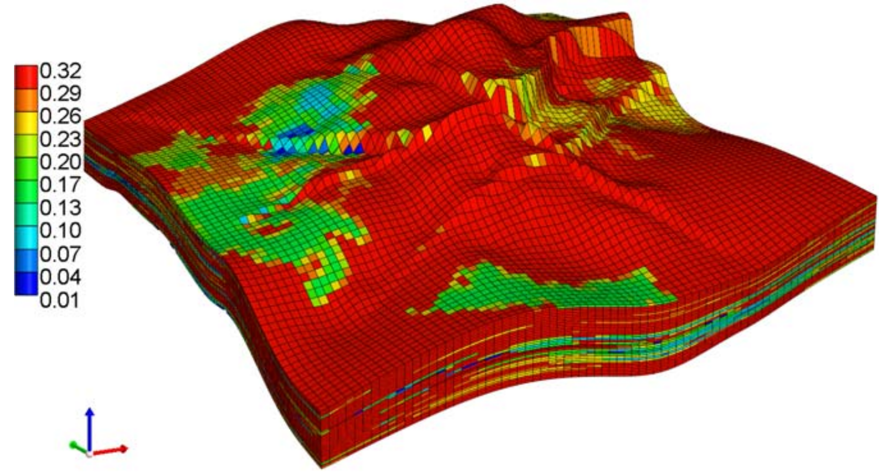
Paradis Petrophysical Data

Zone Depth (ft)



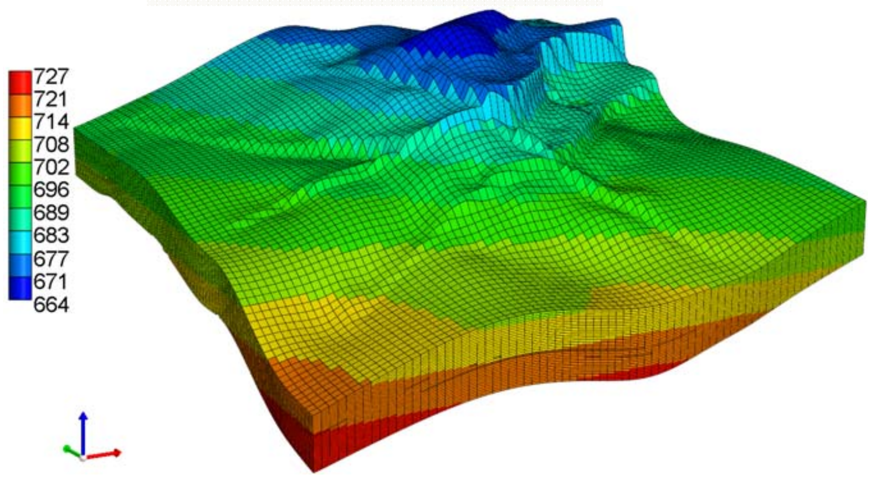
Average thickness = 350 ft

Porosity



Average Porosity = 0.3

CO_2 Density (kg/m3)



Storage capacity

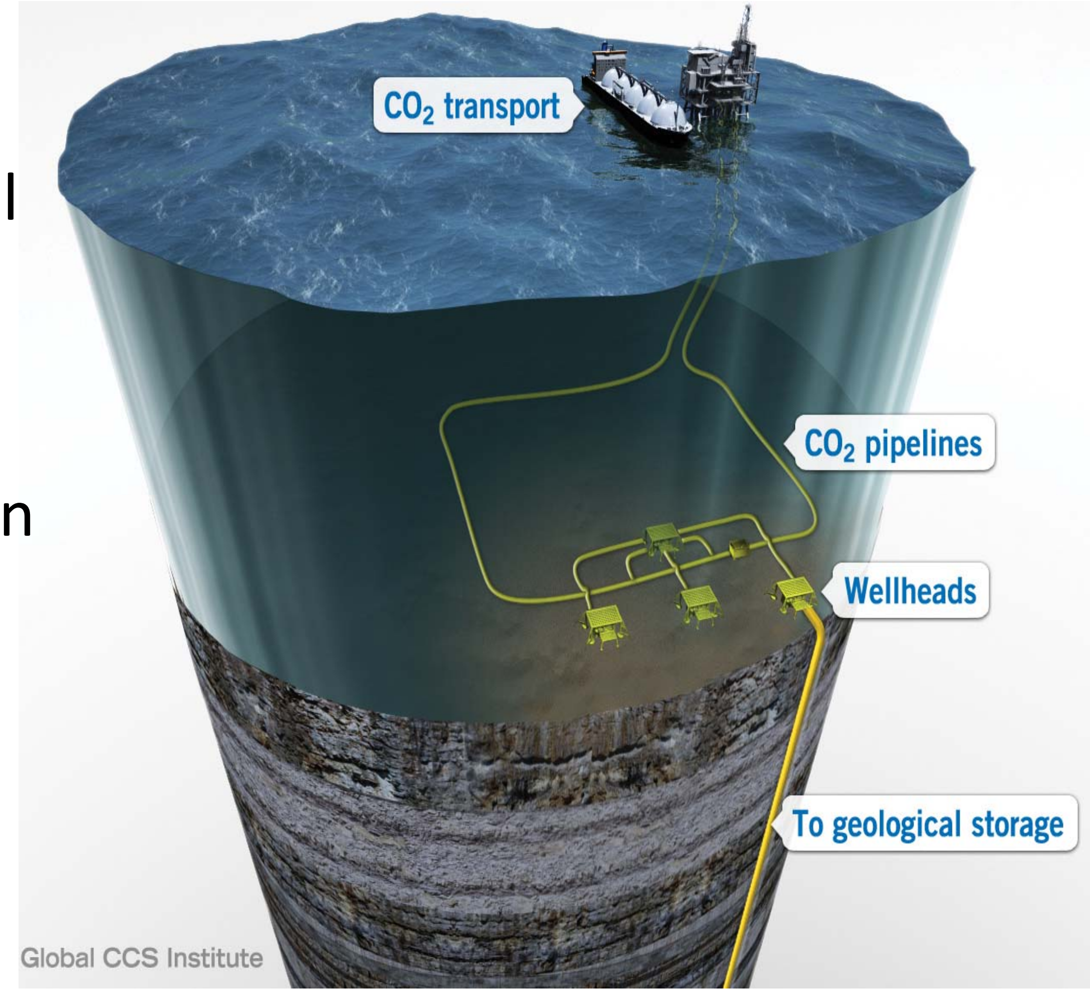
Static Model	Bayou Sorrel	Paradis
Average depth to top of potential storage zone (ft)	7300	4300
Average thickness of potential storage zone (ft)	990	350
Average porosity of potential storage zone (fraction)	0.280	0.300
Average CO2 density (kg/m3)	771.1	714
Static storage efficiency (fraction)	0.020	0.020
Static storage capacity (Mt)	133	84
Static capacity per unit volume (Kg/m3)	4.318	4.284

Dynamic Model Parameters	Bayou Sorrel	Paradis	
		Transmissive Faults	Non-transmissive Faults
No. of wells	7	7	7
Dynamic Capacity (Mt)	129	124	71
Storage efficiency (fraction)	0.019	0.043	0.025
Dynamic capacity (Kg/m3)	4.20	9.29	5.33

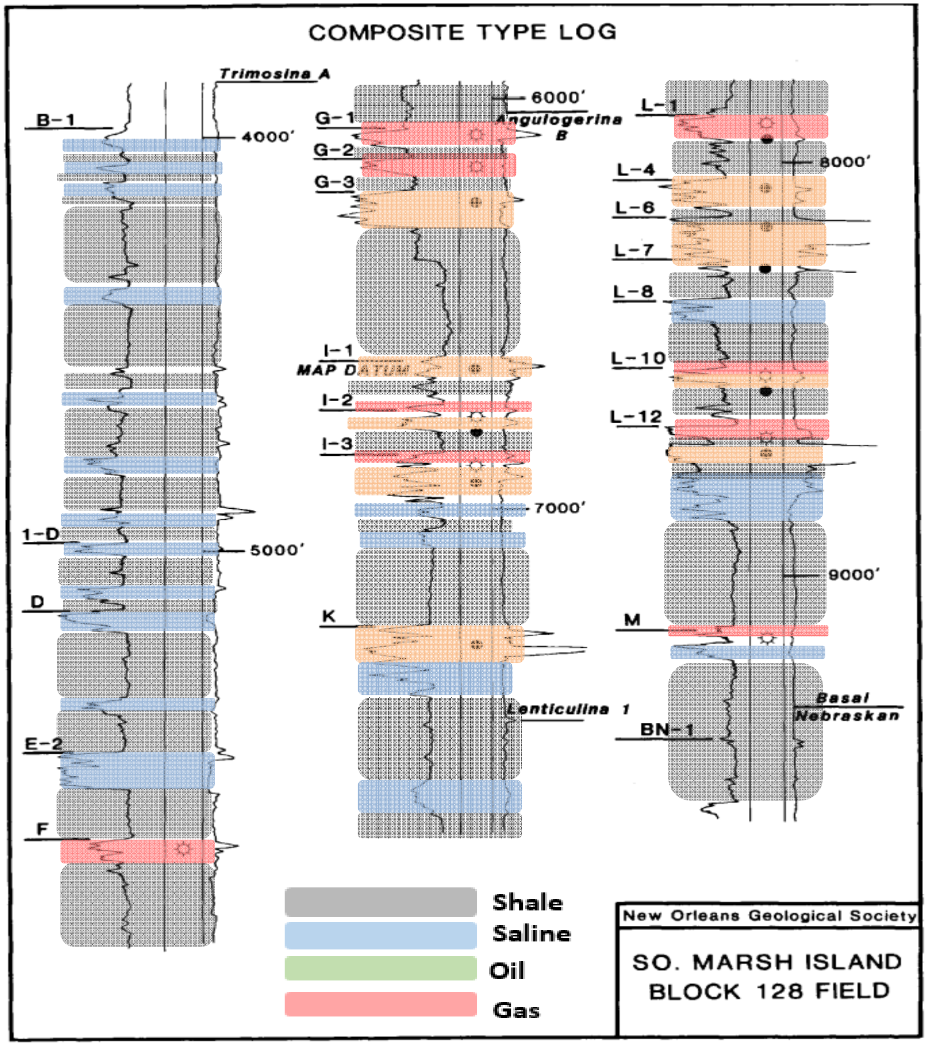
Offshore CCUS

- As part of SECARB offshore GoM partnership, currently looking at CCUS potential in Louisiana state waters

- The evaluation focuses on active and depleted O/G fields and potentially associated CO_2 EOR as well as saline storage resources

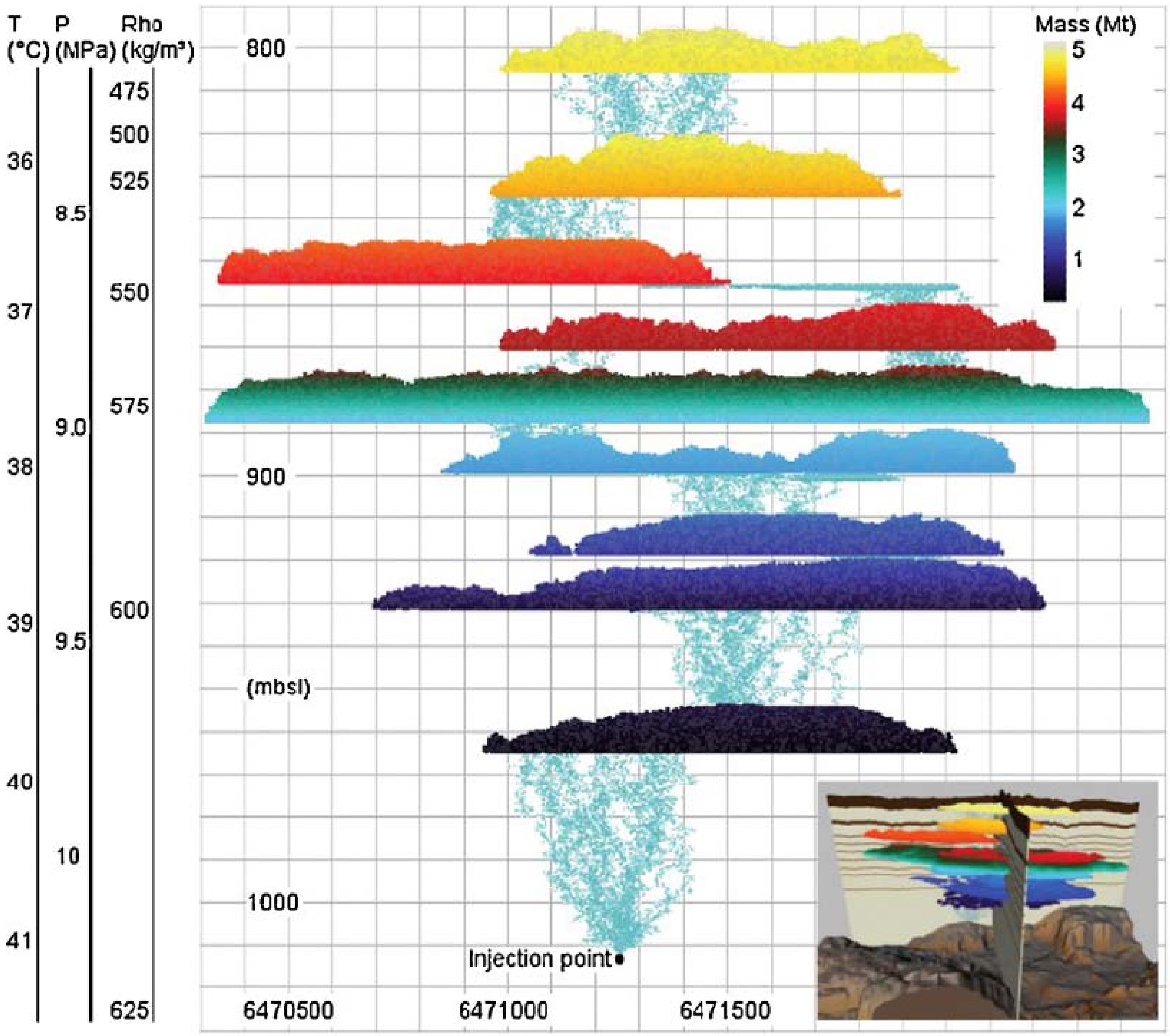


Why CCUS in Louisiana?

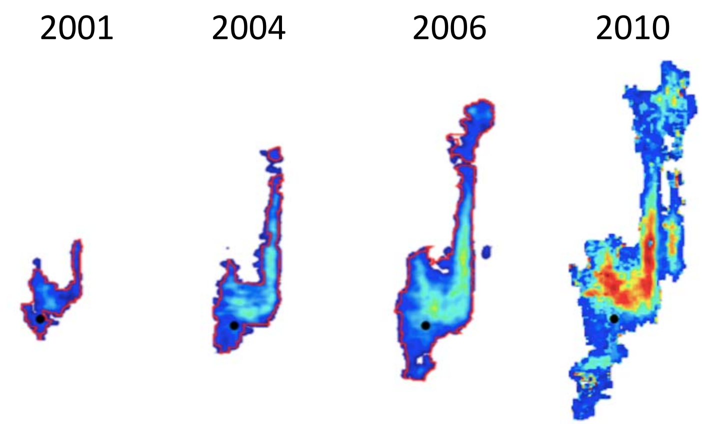


Composite type log, South Marsh Island Block 128 field, offshore Louisiana

Challenges/Barriers



Cavanagh et al., 2014



Chadwick and Noy (2010)
Furre and Eiken (2014)

Smith, 1966

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Molina, O., V. Vilarrasa, and M. Zeidouni (2017), Geologic Carbon Storage for Shale Gas Recovery, Energy Procedia, 114(Supplement C), 5748-5760.

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Questions?

U.S. DEPARTMENT OF ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY

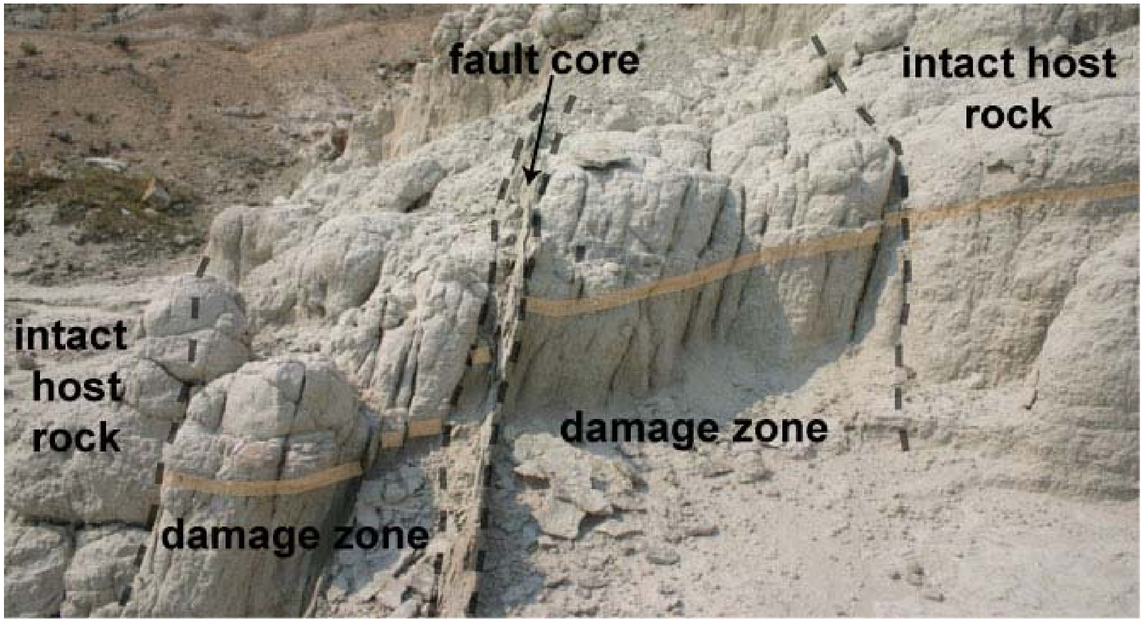
CO2 Utilization

NARUC, 2018

Fault structure

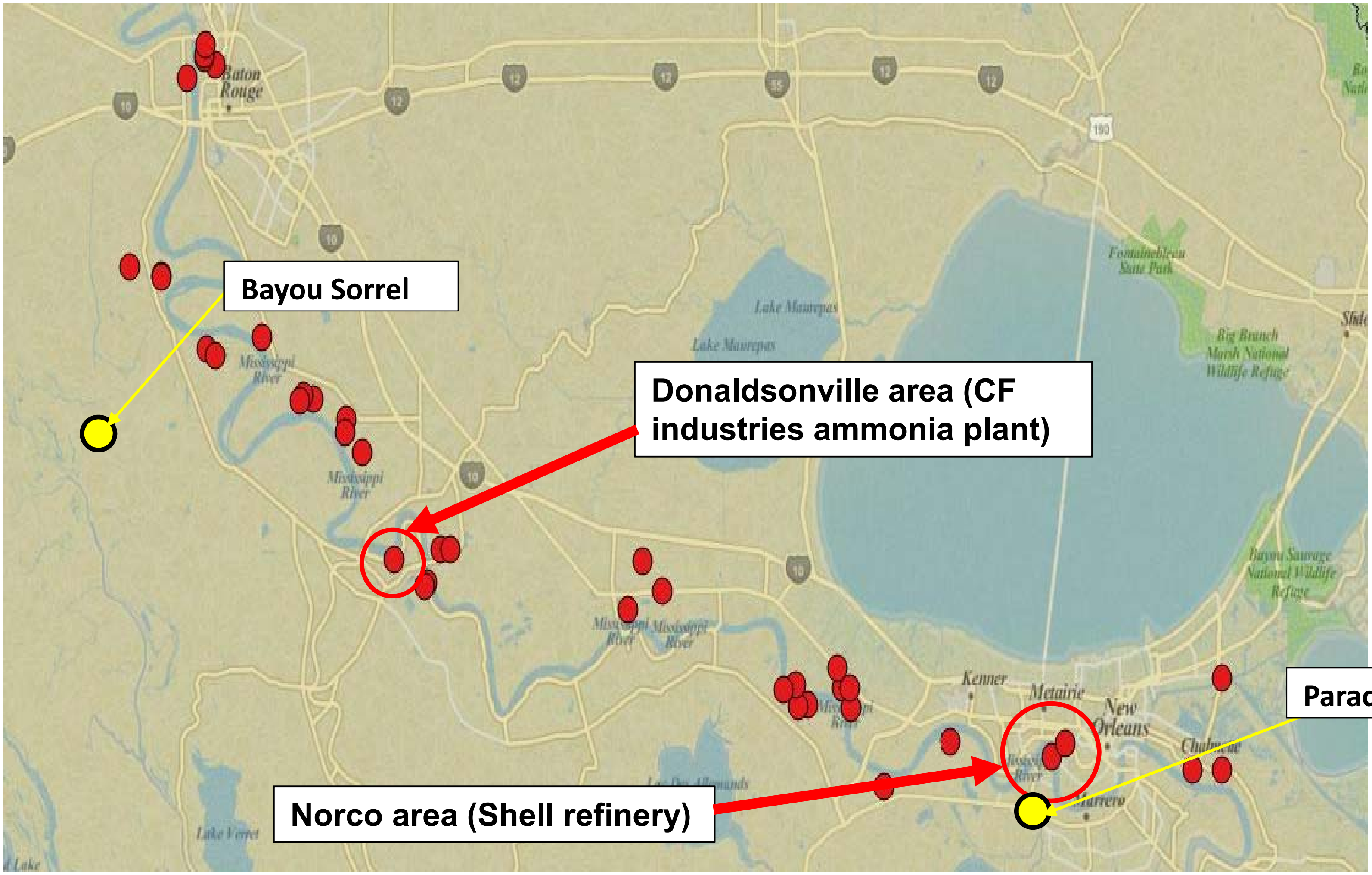
Two-component fault idealization:

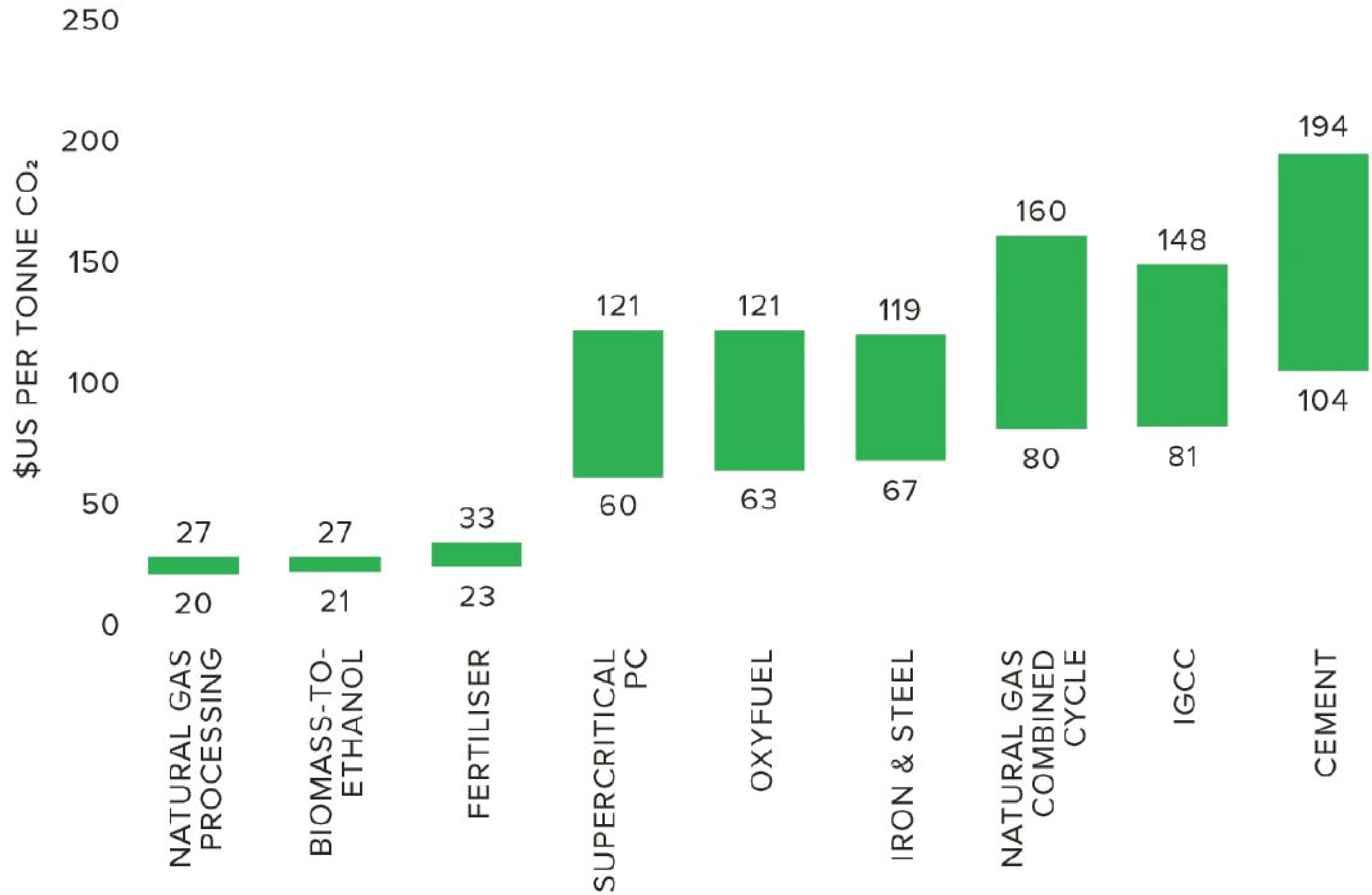
- Fault core
- Fault damage zone



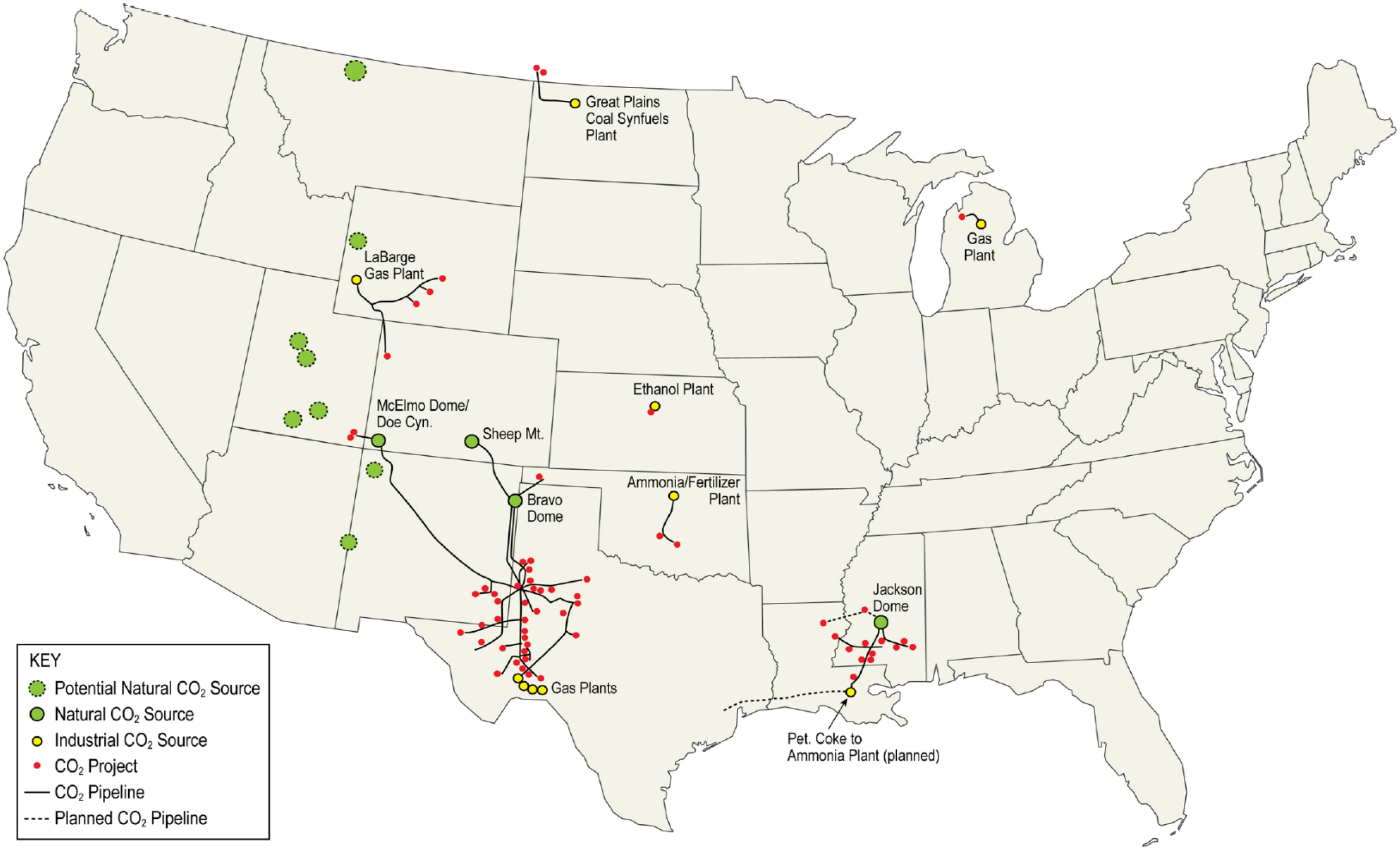
Source: Maher, 2018

Identified saline storage sites





Global CCS Ins., 2017

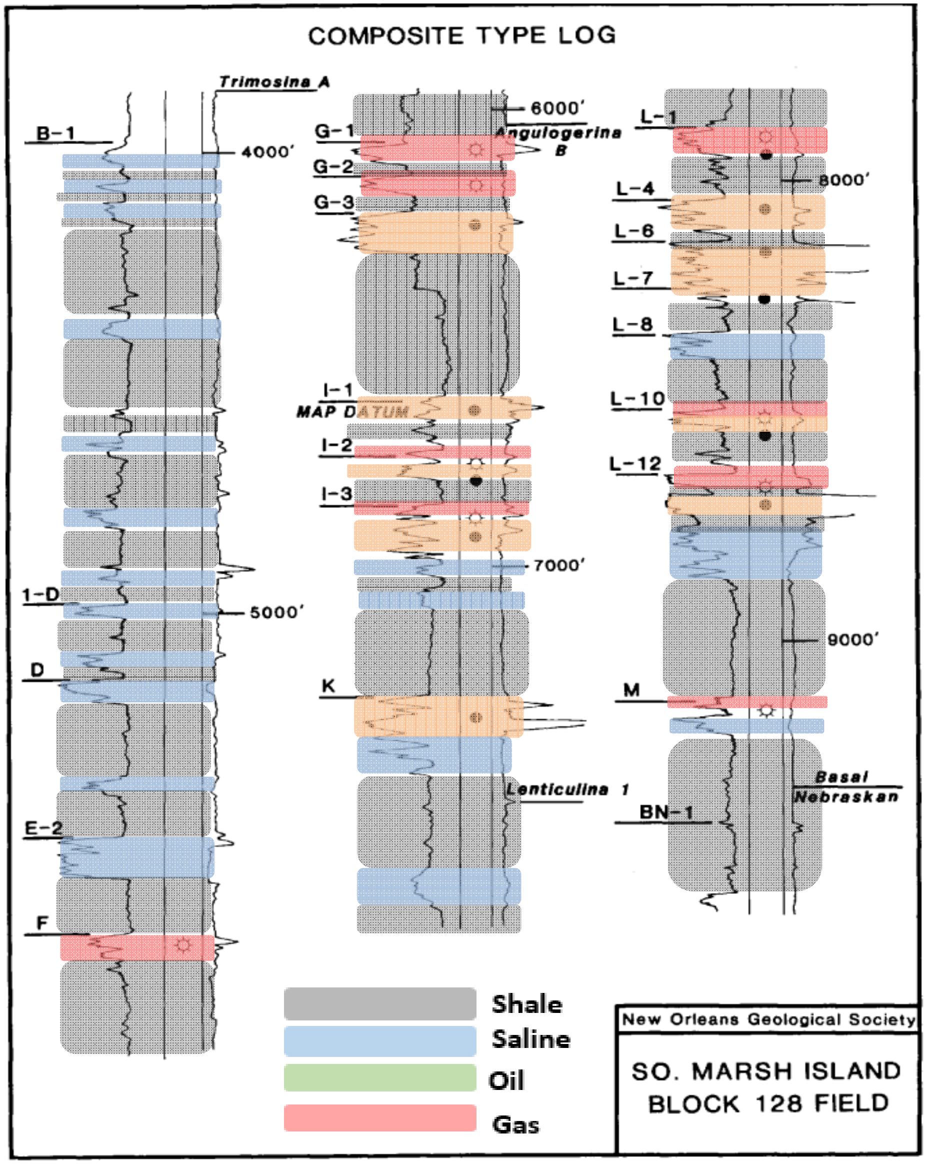


Location of Current CO_2 EOR Projects and Pipeline Infrastructure

NETL, 2010

Louisiana Information

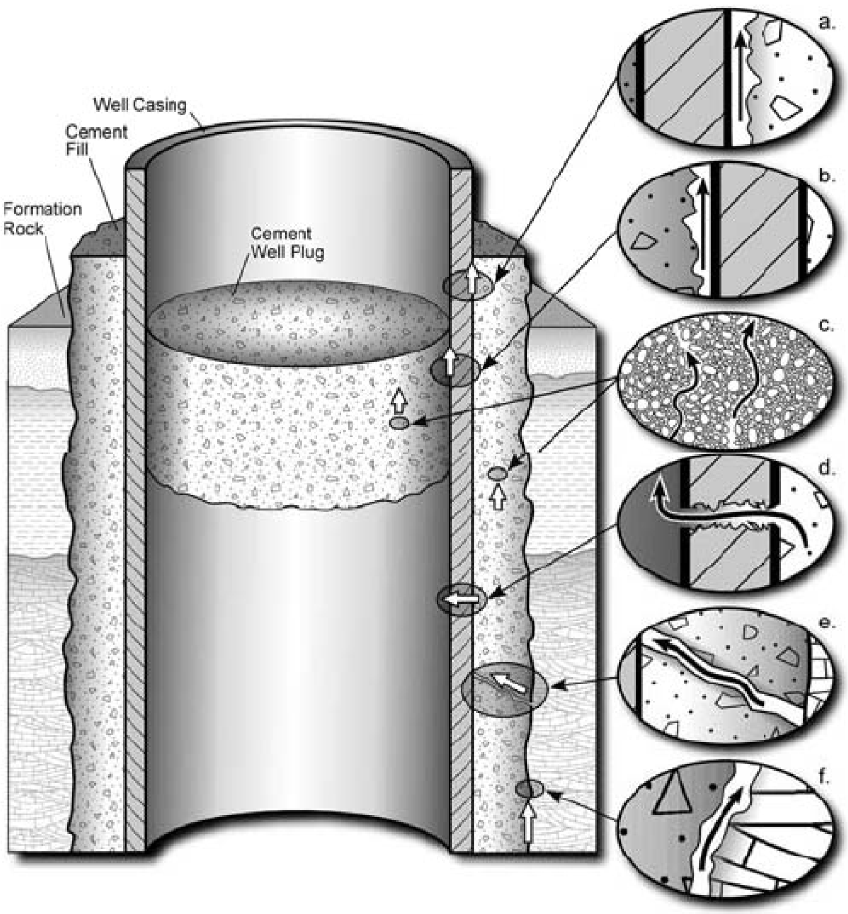
Total Fields	2674
Total wells	242924



Composite type log, South Marsh Island Block 128 field, offshore Louisiana

Shale
Saline
Oil
Gas

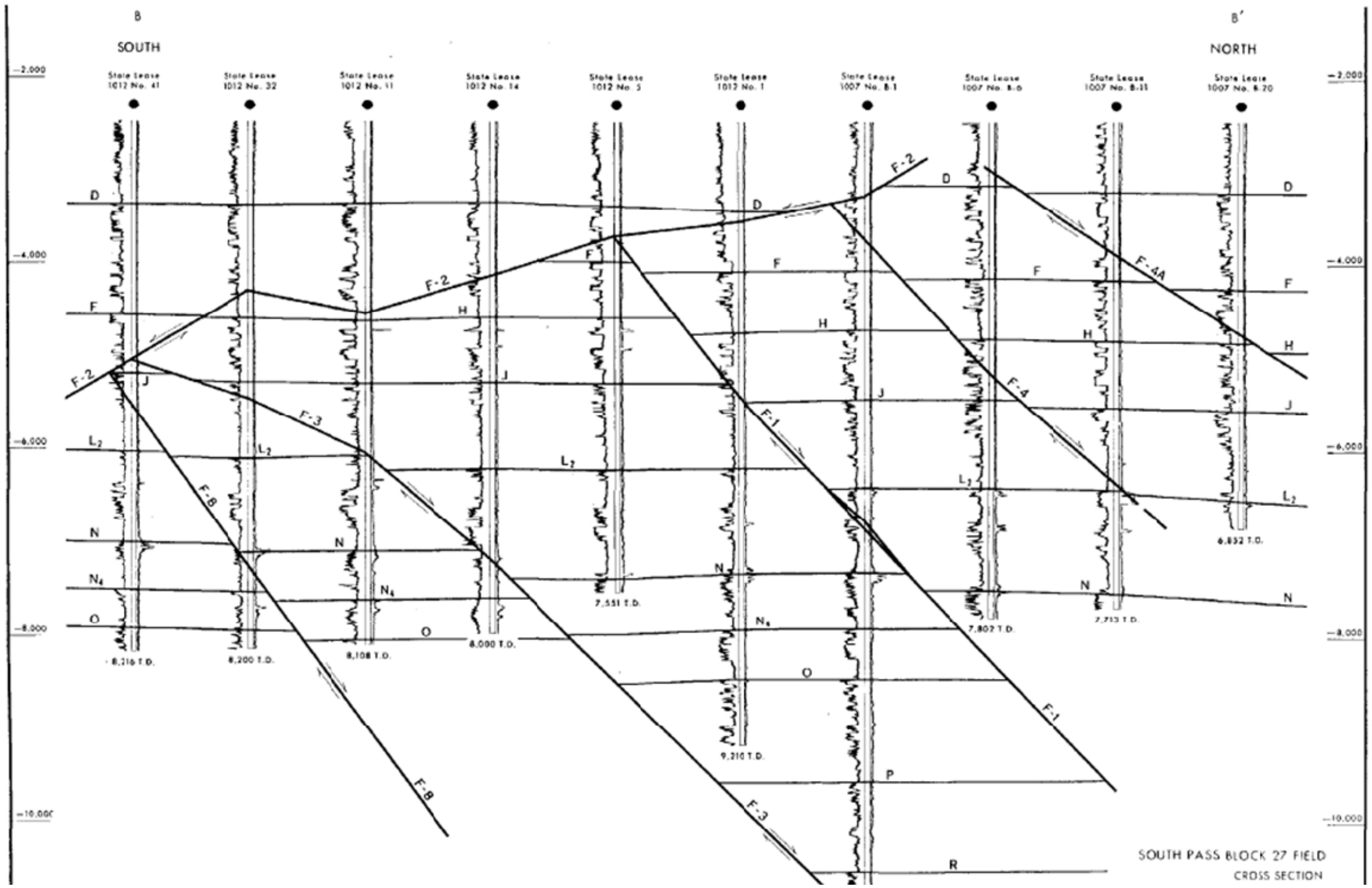
Well leakage



Celia et al., 2005

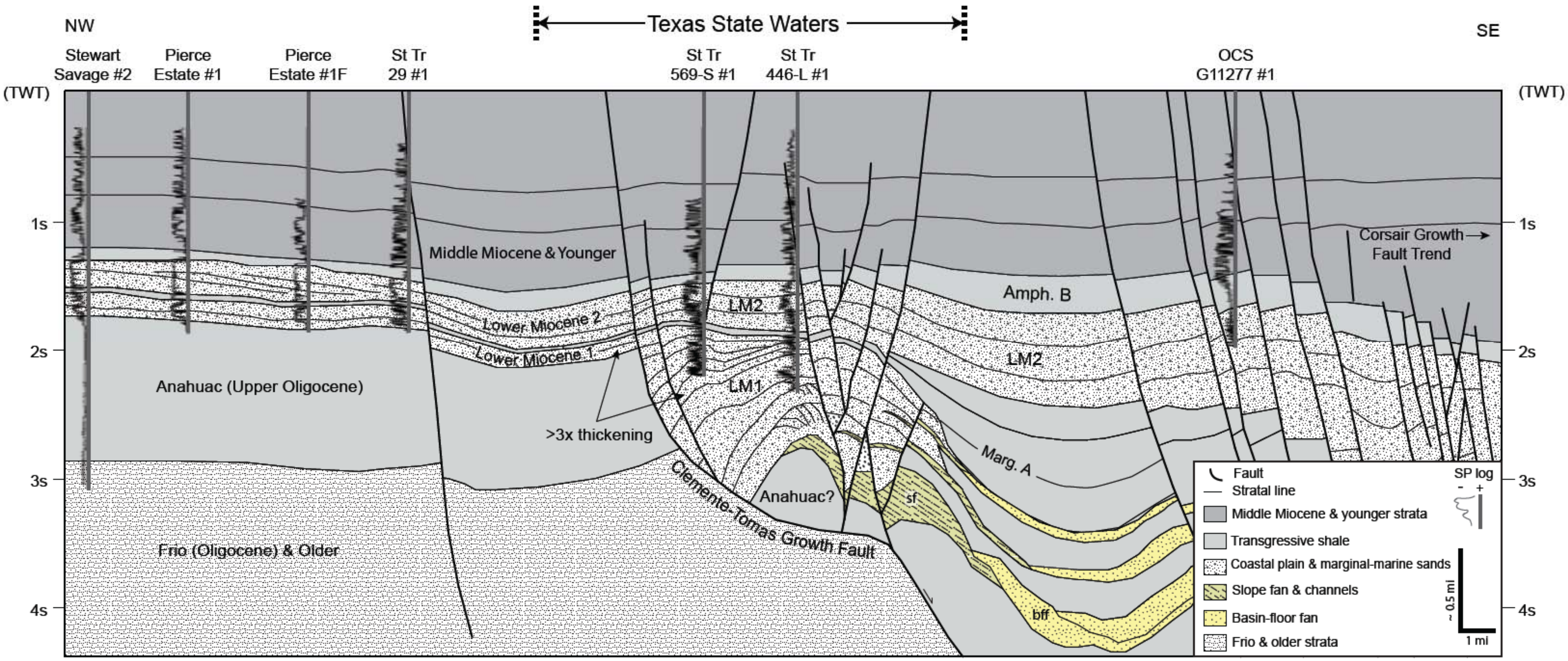
AMES Geology, 2019

Fault leakage



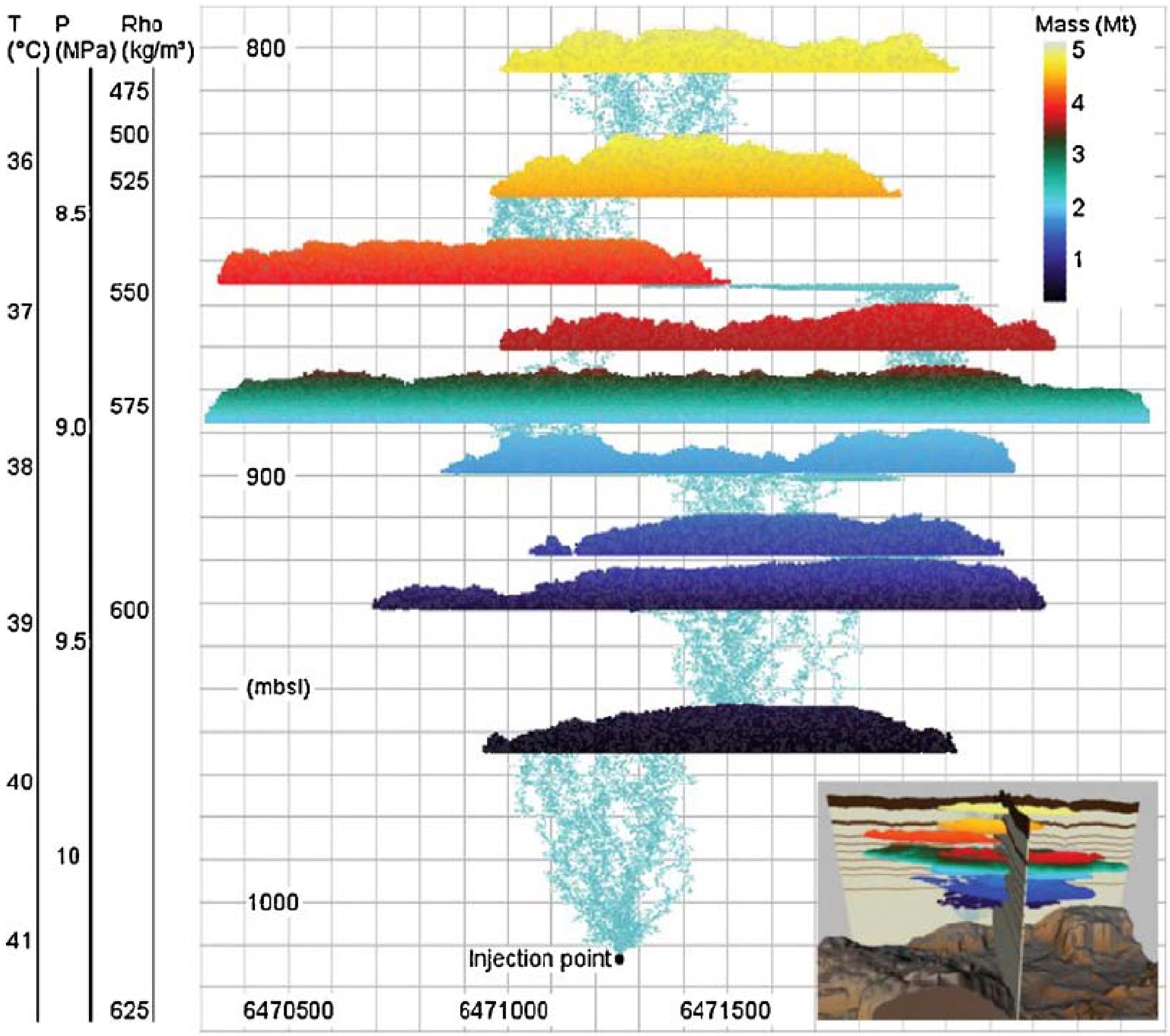
Smith, 1960

Fault leakage

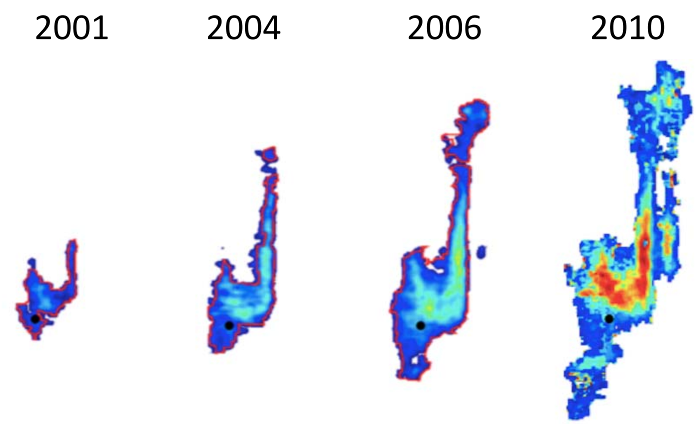


Representative dip-oriented structural cross-section through Texas waters (Nicholson, 2012)

CO_2 plume extent

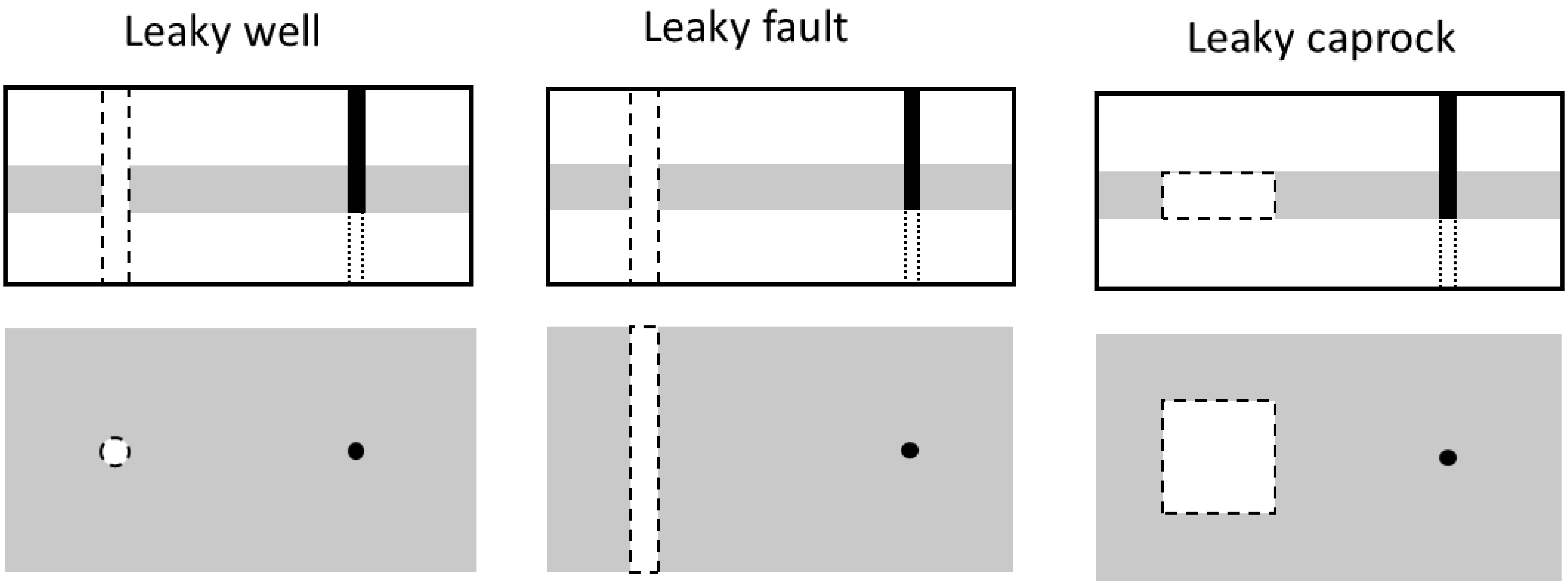


Cavanagh et al., 2014



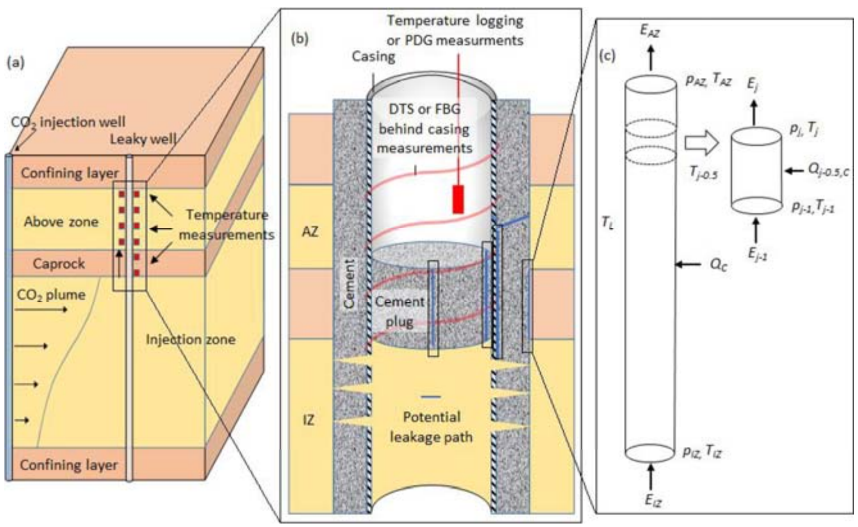
Chadwick and Noy (2010)
Furre and Eiken (2014)

Leak identification

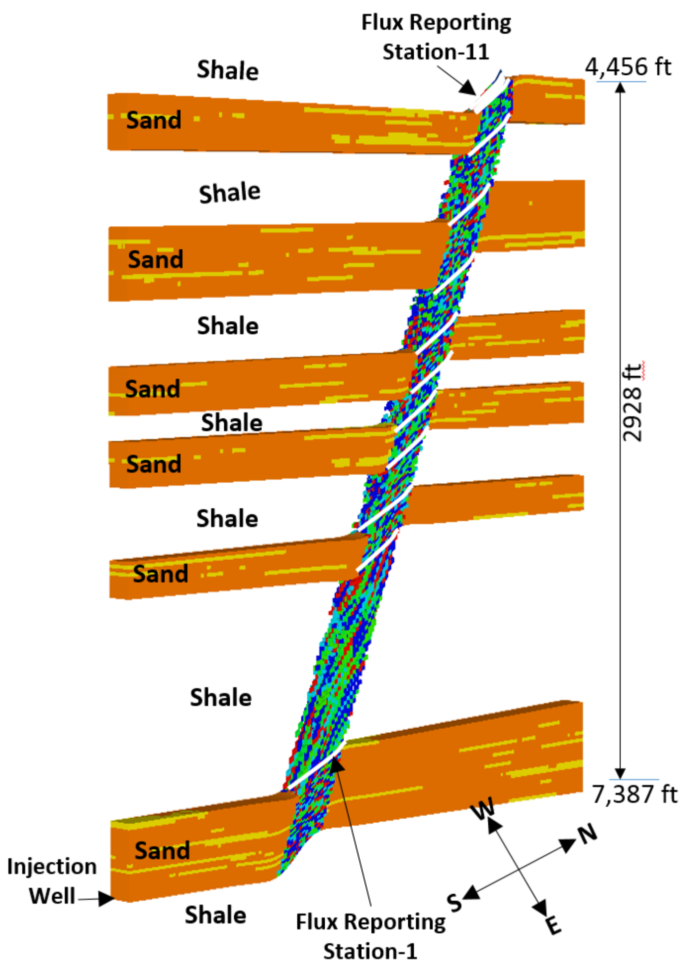


Mosaheb and Zeidouni, 2018

Well/fault leakage detection



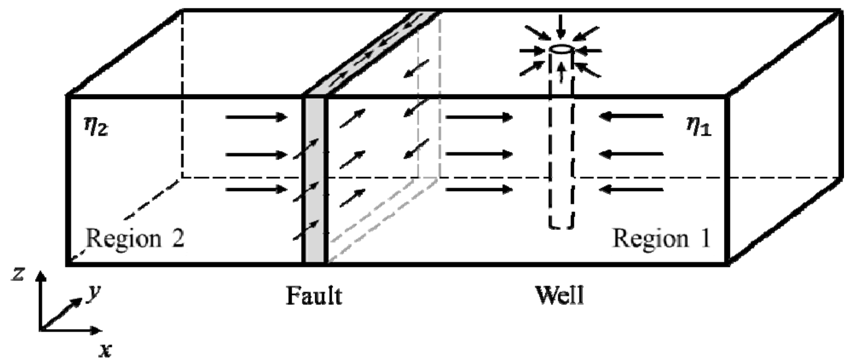
Mao and Zeidouni, 2017

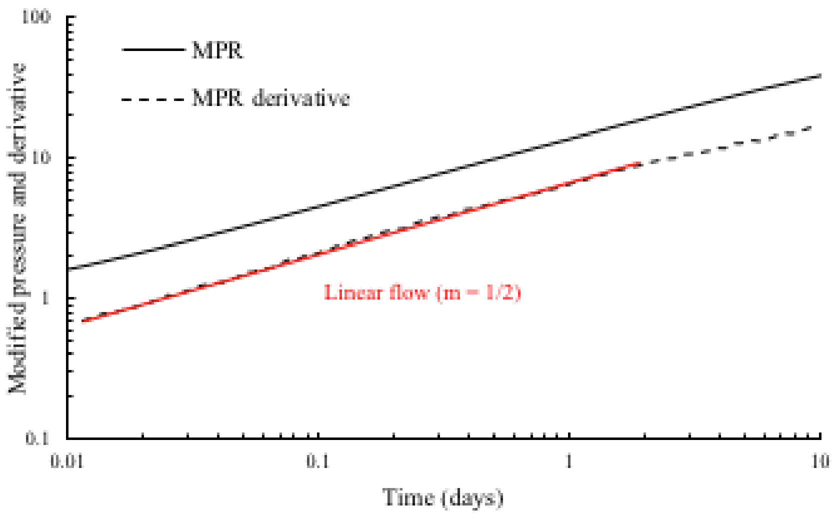


Zulqarnain et al., 2018

Fault leakage monitoring and detection

Fault anisotropy results in linear flow which can be identified through above-zone pressure analysis.

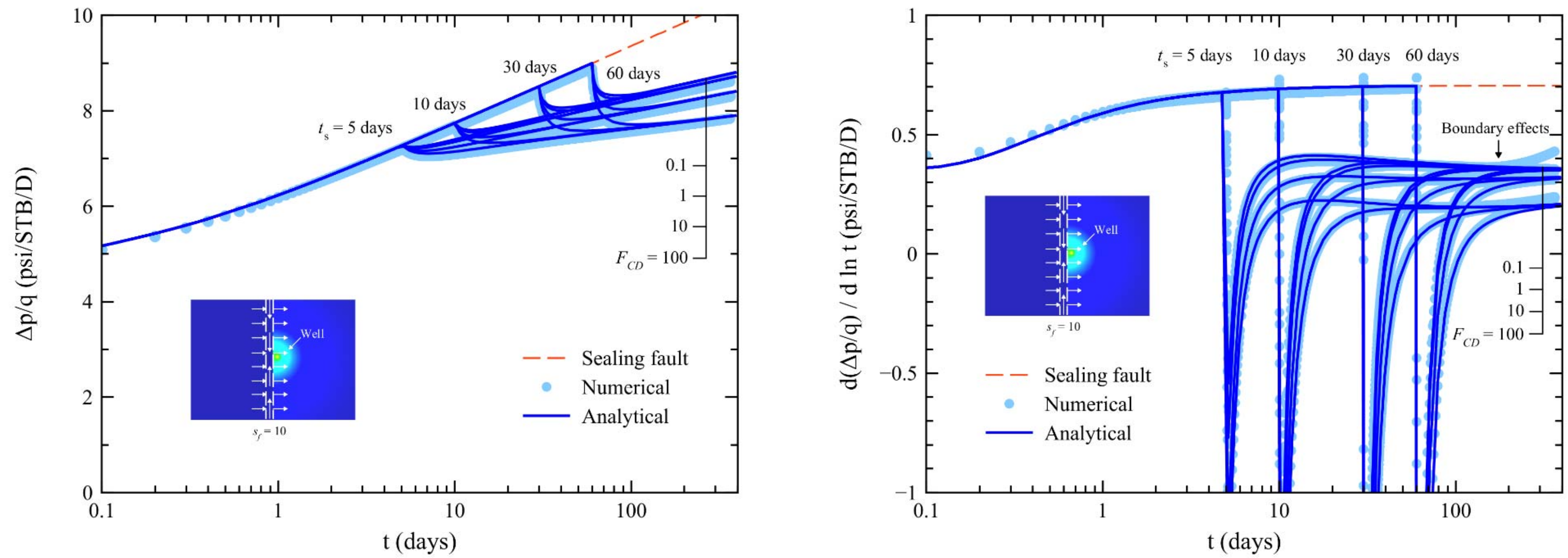




Mosaheb and Zeidouni (2018)

Fault leakage monitoring and detection

Fault reactivation is associated with permeability enhancement the effect of which is observable in the pore pressure signal at the injection well.



Molina and Zeidouni (2018)

Pressure monitoring for plume extent

Three techniques are presented to monitor and analyze pressure to obtain information on the CO_2 plume